Jurnal Ilmiah Telsinas Elektro, Sipil dan Teknik Informasi
Vol.9, No.2, September 2026, pp. 162~174
E-ISSN: 2621-5276
DOI: https://doi.org/10.38043/telsinas.v9i2.7779

A Raspberry Pi Local Server-Based Wearable Device System for Heart Health Monitoring

Alamul Iman[1], Juju juhaeriyah[2]

alamul.324220001@ugj.ac.id [1], juju_juhaeriyah@ugj.ac.id [2]
Electrical Engineering Study Program, Universitas Swadaya Gunung Jati, Indonesia

ABSTRACT

Cardiovascular diseases, including arrhythmia and heart failure, remain major causes of death worldwide. Cloud-based ECG monitoring systems may face challenges related to dependence on internet connectivity and data transmission. This study aimed to develop a prototype of a local-network-based wearable ECG monitoring system using a Raspberry Pi as a local server without relying on public internet connectivity. A modified Research and Development (R&D) method was applied through requirements analysis, system design, prototype development, and system evaluation. The system integrated an AD8232 ECG sensor, an ESP8266 microcontroller, and a Raspberry Pi. ECG data were transmitted in real time through a local Wi-Fi network using HTTP over TCP/IP and stored in a MySQL database. BPM measurements were validated against a pulse oximeter using 10 measurements for each of six participants aged 14–87 years, resulting in 60 measurements in total. The system achieved an average accuracy of 97.75% and an average error of 2.25%. The prototype successfully acquired and recorded raw ECG and BPM data, classified heart rate into predefined normal, bradycardia, and tachycardia categories, and provided corresponding LED indicators. The system is intended for ECG and heart-rate monitoring and does not provide clinical diagnosis of cardiac conditions.

Keywords: *Wearable Device*; Electrocardiogram (ECG); Raspberry Pi

Article Info

Received : 27-06-2026
Revised : 13-08-2026
Accepted : 29-08-2026

Correspondence Author:

Juju Juhaeriyah
Electrical Engineering Study Program,
Universitas Swadaya Gunung Jati,
Jl. Pemuda Raya No. 32 45132 Kesambi Jawa Barat
Email: juju_juhaeriyah@ugj.ac.id

1. INTRODUCTION

The heart plays a vital role as a vital organ that pumps blood throughout the body to ensure the supply of nutrients and oxygen to every tissue. To maintain metabolic stability, physical capacity, and quality of life, the heart must always be in optimal condition. Even the slightest abnormality in the heart's electrical activity can disrupt its rhythm and pumping capacity; if left untreated, this can lead to life-threatening medical conditions. Therefore, heart health monitoring is a vital tool in both the prevention and treatment of various health conditions [1].

The risk of developing heart problems tends to increase with age, a condition that is exacerbated by external risk factors such as stress levels, unhealthy lifestyle habits, and a lack of physical activity. In modern society, cardiovascular disorders such as heart failure, atrial fibrillation, and arrhythmia remain among the leading causes of poor health and death [2]. This phenomenon demonstrates that early detection through monitoring of the heart's electrical signals is crucial for preventing more severe complications. To monitor the function of this organ in detail, monitoring devices are needed that can continuously and accurately record data on the heart's electrical activity one such method is the electrocardiogram (ECG) [3].

An ECG is the most commonly used diagnostic tool for assessing the heart's function and clinical condition. Data regarding heart rate, rhythm, and signs of heart abnormalities can be quickly identified through ECG signal recording [4]. Thanks to the introduction of the latest technological innovations, the use of ECGs is no longer limited to clinical settings or conventional healthcare facilities, but has evolved into portable and wearable devices. Wearable ECG has become a practical alternative to conventional ECG systems because it enables portable cardiac monitoring during daily activities [5]. This shift has been driven by advances in the miniaturization of electronic components and sensors, which make it easier for individuals to record heart signals on their own without having to rely on large, heavy conventional instruments [6]. This wearable ECG device offers a practical solution because it is lightweight, ergonomic, and capable of continuously monitoring heart condition while the user goes about their daily activities [7]. Wearable ECG technology also supports non-invasive long-term monitoring, making it suitable for continuous heart health assessment [8].

In the design of modern wearable devices, the ESP8266 microcontroller is often chosen as the primary processing unit due to its reliable performance and built-in Wi-Fi module support for wireless data transmission. In the design of modern wearable devices, the ESP8266 microcontroller is selected as the primary processing unit due to its built-in Wi-Fi capability, which enables wireless transmission of acquired ECG data. In this system, the ESP8266 receives ECG signals from the AD8232 sensor and transmits the acquired data via a local Wi-Fi network to a Raspberry Pi-based local server for real-time monitoring and data storage [9].

Unlike cloud-based mechanisms that require global internet connectivity, this study uses a local server operating on a local Wi-Fi network to improve efficiency, strengthen data protection, and reduce reliance on external internet providers. Edge-based healthcare architecture can reduce dependence on cloud infrastructure by processing health data closer to the data source [10].

In this architecture, the Raspberry Pi is serves as a local server that bridges data communication within a single Wi-Fi network in conjunction with the ESP8266. This Raspberry Pi microcomputer is responsible for running server services, processing the database, and managing the Application Programming Interface (API) to receive, archive, and display real-time ECG data visualizations [11].

Previous research has demonstrated that Raspberry Pi can be effectively used as an embedded platform for ECG monitoring, including real-time acquisition and processing of ECG signals [12].

Using a local server provides multi-layered protection, ranging from significantly shorter data transfer times (latency) to enhanced data privacy, as medical data is not exposed to the public internet. Fog or local computing approaches are useful in healthcare monitoring because they can support faster notification and local data handling [13]. Additionally, the system continues to function optimally even if the global internet connection is interrupted. Through the synergy between the ESP8266 as the data acquisition unit and the Raspberry Pi as the server, a reliable, cost-effective, and efficient heart health monitoring system can be realized.

The main contribution of this study is the integration of an AD8232-based ECG sensor, an ESP8266 microcontroller, and a Raspberry Pi local server into a wearable monitoring system that supports real-time ECG acquisition, local data transmission, and centralized storage without transmitting health data through the public internet. This architecture provides a self-contained approach for wearable ECG monitoring within a local network environment.

Based on this approach, the Raspberry Pi is utilized as the local server in the development of the wearable heart health monitoring system. The proposed architecture focuses on enabling real-time ECG monitoring and structured local data storage while maintaining independence from public internet connectivity. The system was subsequently evaluated in terms of ECG measurement accuracy, heart-rate classification, and data transmission performance to assess its functional performance.

2. RESEARCH METHOD

This study employed a modified Research and Development (R&D) method to design, develop, and evaluate a wearable Electrocardiogram (ECG) monitoring system. The R&D method was adapted to the scope of this study, which focused on the development and evaluation of a functional prototype rather than mass production and large-scale dissemination. The research consisted of several stages: preliminary study and literature review, system requirements analysis, system design, system development, module testing, integrated system testing, performance evaluation, and data analysis. The research workflow is presented in Figure 1.

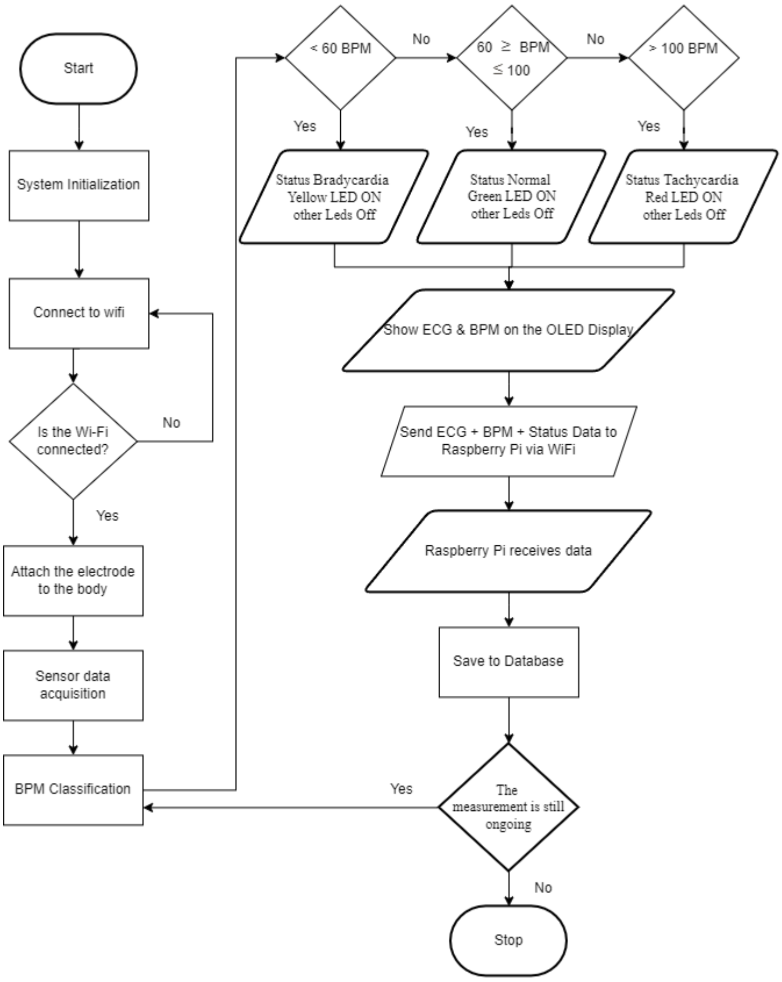

Figure 1. Flowchart

The preliminary study and literature review were conducted to understand ECG signal acquisition, the use of the ESP8266 for wireless communication, and the implementation of a Raspberry Pi as a local server [2] literature review also considered previous studies related to wearable ECG monitoring systems [14]. ESP8266-based communication, and Raspberry Pi-based data storage [15]. The results of the literature review were used as the basis for designing the system's hardware, software, and database.

The system design included the development of the system architecture, ECG sensor interface, data transmission interface, and database on the Raspberry Pi [6] The ESP8266 was configured to transmit ECG data in real time over a local Wi-Fi network using the HTTP protocol. The Raspberry Pi received the transmitted data through an API and stored it in the database [15].

Testing was conducted in two phases: module testing and integrated system testing. Module testing was performed to verify that the AD8232 ECG sensor could acquire ECG signals and that the ESP8266 could process and transmit data via Wi-Fi. On the server side, the Raspberry Pi was tested to ensure that it could consistently receive and store ECG data.

integrated system testing was conducted to assess the overall performance of the system based on ECG signal quality, wi-fi connection stability, data transmission latency, and data storage reliability on the raspberry pi [16]. a local wi-fi network was chosen because it supports real-time data transmission with low latency without relying on an external internet connection. in addition, a local server based on a raspberry pi simplifies data management and control over the storage system [17].

a) System Requirements Analysis

The first stage was system requirements analysis. At this stage, the hardware and software requirements of the proposed system were identified. The hardware requirements included the AD8232 ECG sensor, ESP8266 microcontroller, OLED display, LED indicators, and Raspberry Pi. The software requirements included the microcontroller program, Wi-Fi communication, HTTP-based data transmission, server-side API, and database. The system requirements were determined based on the intended functions of real-time ECG monitoring, BPM classification, wireless data transmission, and centralized data storage.

.

b) System Design

The system design stage was carried out to develop the overall architecture and operational structure of the proposed wearable ECG monitoring system based on the requirements identified in the previous stage. The design focused on integrating the ECG acquisition unit, data processing unit, local wireless communication, user interface, and centralized data storage into a single system. The interaction among these components was designed to support real-time ECG data acquisition, BPM calculation and classification, local monitoring, wireless data transmission, and centralized storage on the Raspberry Pi server.

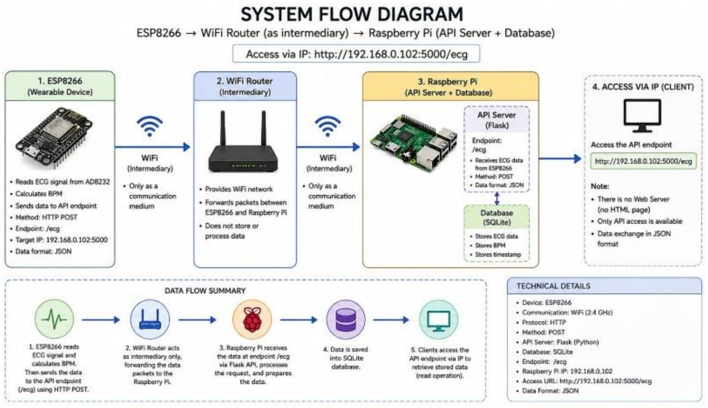

Figure 2. System Flow Diagram

The system architecture was designed to define the interaction between the ECG sensor, ESP8266, OLED display, local Wi-Fi network, and Raspberry Pi server. The AD8232 sensor was used to acquire ECG signals, while the ESP8266 processed the acquired data and transmitted the ECG value, BPM, and monitoring status through the local Wi-Fi network. The OLED display was used to present the ECG value and BPM locally. The Raspberry Pi functioned as the local server responsible for receiving and storing the transmitted data in the database.

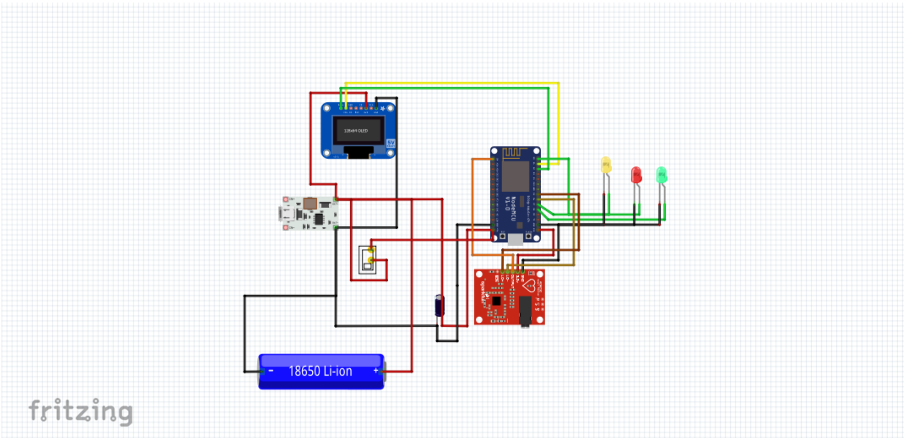

Figure 3. Wiring design

The hardware wiring design of the proposed wearable ECG monitoring system is illustrated in Figure X. The system integrates the AD8232 ECG sensor, ESP8266 microcontroller, OLED display, three LED indicators, power supply circuit, rechargeable 18650 Li-ion battery, and an on/off switch. The AD8232 acquires the heart's electrical activity through the electrodes and provides the ECG signal to the ESP8266 for processing and BPM calculation.

The ESP8266 functions as the main processing unit and controls the OLED display and LED indicators. The OLED displays the ECG value and BPM information, while the three LEDs provide visual indications corresponding to the predefined normal, bradycardia, and tachycardia conditions. The ESP8266 also transmits the processed monitoring data to the Raspberry Pi through the local Wi-Fi network.

The wearable device is powered by a rechargeable 18650 Li-ion battery through the power supply circuit. An on/off switch is placed in the main power path to control the operation of the entire device. When the switch is turned on, the power is distributed to the system components, while turning the switch off disconnects the power and deactivates the device. The overall wiring is arranged to support compactness, portability, and independent operation of the wearable prototype.

c) System Development

The third stage was system development. The hardware and software designs were implemented into a functional prototype. The ESP8266 was programmed to acquire ECG data from the AD8232 sensor, calculate BPM, classify the BPM into bradycardia, normal, and tachycardia conditions, control the corresponding LED indicators, display monitoring information on the OLED, and transmit the data to the Raspberry Pi. On the server side, the Raspberry Pi was configured with an API to receive the transmitted data and store the data in the database.

The developed hardware was then assembled into a compact enclosure to implement the proposed system as a wearable device. The arrangement of the electronic components, battery, display, and electrode connections was considered to support portable operation. The physical design and wearability characteristics of the prototype are described in the following subsection.

d) Physical Design and Wearability of the Device

The physical design of the proposed system was developed to implement the ECG monitoring system as a wearable device. The prototype consists of an AD8232 ECG sensor, ESP8266 microcontroller, OLED display, LED indicators, battery, and protective enclosure. The electronic components were arranged inside the enclosure to provide a compact and portable configuration suitable for body-attached monitoring. The ESP8266 and AD8232 were positioned inside the enclosure, while the OLED display was placed in a visible position to allow the user to observe the monitoring information during operation.

The ECG electrodes were connected to the AD8232 module through electrode cables and attached to the user's skin according to the selected single-lead ECG configuration. Three electrodes were used, consisting of the right arm (RA), left arm (LA), and right leg (RL) electrodes. The RA electrode, identified by the red cable, was placed on the right side of the chest, while the LA electrode, identified by the yellow cable, was placed on the left side of the chest. The RL electrode was placed on the lower right side of the abdomen and served as the reference electrode. This electrode configuration was maintained consistently throughout the experiment to support stable ECG signal acquisition and ensure comparable measurements between testing sessions. The electrode placement used during the experiment is presented in Figure 4.

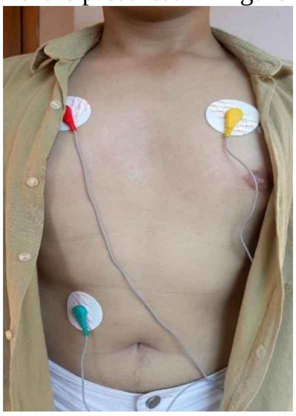

Figure 4. Electrode Position

The wearable prototype was equipped with a protective enclosure to protect the electronic components and facilitate portable use. The physical dimensions of the prototype were 12,5cm × 8,5cm×, with a total weight of approximately 143g. The system was powered by a Lithium 18650 with a capacity of 1200mAh. The battery supplied power to the ESP8266, AD8232 sensor, OLED display, and LED indicators during operation. The operating duration of the device was evaluated under continuous ECG monitoring and wireless data transmission.

The physical design also considered user comfort and ease of use. The enclosure was designed to minimize the size and weight of the device, while the electrode cables were arranged to reduce interference during use. The prototype was intended to support short-duration ECG monitoring while allowing the user to carry the sensing and processing unit without requiring a direct connection to an external power source or computer. The physical implementation of the wearable prototype is shown in Figure 5.

.

Figure 5. Design Wearable

e) Module Testing

The stage was module testing. Each major component of the system was tested individually before the components were integrated. The AD8232 module was tested to verify ECG signal acquisition, while the ESP8266 was tested to verify data processing, BPM calculation, LED control, OLED display, and Wi-Fi communication. The Raspberry Pi server was also tested to verify its ability to receive data through the API and store the received data in the database. The purpose of module testing was to identify and correct functional problems before integrated system testing.

f) Integrated System Testing

The fifth stage was integrated system testing. At this stage, all hardware and software components were connected and operated as a complete system. The testing evaluated the complete data flow, starting from ECG signal acquisition by the AD8232 sensor, processing and BPM classification by the ESP8266, display of monitoring information on the OLED, transmission through the local Wi-Fi network, reception by the Raspberry Pi API, and storage in the database.

2.1 Electrocardiogram

An electrocardiogram or ECG is a graph of the heart's electrical activity obtained through electrodes on the skin's surface [18] An ECG signal typically consists of the P wave, the QRS complex, and the T wave, which are used to analyze the heart’s function, including the detection of arrhythmias and other heart conditions [15].

In wearable systems, ECG sensors are used to collect data in real time and non-invasively, making them suitable for long-term monitoring [4]. However, ECG signals can be affected by disturbances such as motion artifacts caused by body movement and powerline interference from electrical networks. Therefore, signal amplification and filtering are necessary to ensure that the data obtained is more stable [6].

2.2 ESP8266

The ESP8266 is a microcontroller with built-in Wi-Fi connectivity, making it suitable for use in local area networks [7]. In this study, the ESP8266 serves as a unit for reading and transmitting ECG data from the sensor to a local server. The ECG data obtained from the sensor is processed in a simple manner by the ESP8266 and then transmitted to the Raspberry Pi via a local Wi-Fi network. The use of the ESP8266 facilitates the creation of portable devices due to its small size and relatively low power consumption [9]. The initial processing may include reading sensor data, setting transmission intervals, and applying simple filters before the data is transmitted [11]

2.3 Raspberry Pi

The Raspberry Pi is used as a local server to receive, process, and store ECG data [17]. This device can run Linux-based operating systems as well as database applications such as MySQL or SQLite, allowing data to be stored in a structured manner [19]. Raspberry Pi also has the potential to support local ECG analysis, including lightweight classification models for future system development [20].

Using a Raspberry Pi as a local server offers the advantages of flexibility, relatively low cost, and ease of data management and storage. This system supports a local network-based health monitoring concept, in which wearable devices collect data, and the Raspberry Pi serves as the central hub for data management and storage before the data is displayed or analyzed further.

2.4 Integration System Wearable

The integration of ECG sensors, the ESP8266, and the Raspberry Pi is a key component in the development of wearable ECG monitoring systems [21]. The development of wearable ECG systems generally requires proper integration between the sensing unit, processing unit, and data management system [13]. The ECG sensor reads the heart's electrical activity, the ESP8266 transmits the data wirelessly, and the Raspberry Pi stores the data centrally.

In addition to technical considerations, the design of the wearable must also prioritize user comfort. The comfort and usability of wearable ECG devices are important factors because the device may be used repeatedly or for extended monitoring periods [22]. The device must be designed to be ergonomic, lightweight, and comfortable to wear so that it can support long-term monitoring [23]. Thus, the developed system can serve as an alternative solution for heart health monitoring based on a local server using a local network.

2.5 Formula Packet Loss Rate (PLR)

In this study, the Packet Loss Rate (PLR) was calculated to determine the rate of data packet loss during transmission from the microcontroller to the local server. The PLR value was obtained by comparing the amount of lost data to the total data sent, then multiplying the result by 100%. The lower the PLR value, the better the data transmission quality in the local network-based ECG monitoring system [24].

Packet loss is an important parameter in ECG data transmission because lost packets may affect the reliability of real-time monitoring [25].

2.6 Accuracy Formula

In addition to data transmission testing, error values were calculated to determine the degree of agreement between the prototype system's readings and those of the standard device. Absolute error values were used to calculate the difference between the heart rate (HR) values obtained from the prototype and those from the standard device. Furthermore, the relative error percentage was used to determine the magnitude of the reading error as a percentage. These error calculation results were used as a basis for assessing the system's accuracy in reading BPM values.

3. RESULTS AND DISCUSSION

In this study, we successfully developed a wearable device system for monitoring heart health based on the ESP8266 with a Raspberry Pi serving as the server. The system consists of four main components, namely:

a) Wearable device (sensors and data acquisition)
b) Cardiac health monitoring
c) Local Wi-Fi-based data transmission system
d) Centralized server and data storage system

The system was evaluated using data collected from six participants, as presented in Table 1. For each participant, ECG measurements were conducted repeatedly according to the predefined testing procedure. Table 2 presents selected observation results from these repeated measurements; therefore, the same participant characteristics, such as age and gender, may appear multiple times. These repeated observations do not represent additional participants but indicate repeated measurements performed on the same participant. The repeated measurements were conducted to assess the consistency and accuracy of the developed system.

3.1 ECG Sensor Accuracy Testing

The purpose of this test is to determine the accuracy of the AD8232 ECG sensor in measuring heart rate (BPM) compared to a reference device.

.

Table 1. Data Accuracy Sensor

No	Gender	Age	ECG	Oximeter	Error	Accuracy
1	Male	23	72	74	2,70%	97,30%
2	Female	48	71	74	4,05%	95,95%
3	Male	57	88	90	2,22%	97,78%
4	Female	87	90	91	1,09%	98,91%
5	Male	33	84	87	3,44%	96,56%
6	Male	14	74	74	0%	100%
Average on					2,25%	97,75%

Based on the test results from six participants aged 14–87 years, the heart rate measurements obtained from the developed ECG device were compared with those from a pulse oximeter as the reference device. The percentage error was calculated using the pulse oximeter reading as the denominator, according to the following equation:

$$Error\% = \frac{HRreferences - HRsensor}{HRreferences} \, x \, 100\% \qquad (1)$$

The measurement accuracy was subsequently calculated as:

$$Accuracy\% = 100\% - Error(\%) \qquad (2)$$

The highest error was observed in the 48-year-old female participant at 4.05%, whereas the lowest error was 0.00% in the 14-year-old male participant. Based on the values presented in Table 1, the average error was 2.25%, corresponding to an average accuracy of 97.75%. These results indicate that the developed ECG device demonstrated good agreement with the pulse oximeter in measuring heart rate under the tested conditions.

3.2 Heart Health Monitoring

Heart health monitoring based on beats per minute (BPM) is used to evaluate the heart's performance in real time. The BPM value indicates the number of heart beats per minute, which can be obtained via ECG or PPG sensors. Generally, an adult’s heart rate is classified into three categories: normal (60–100 BPM), bradycardia (less than 60 BPM), and tachycardia (more than 100 BPM). The designed system does not utilize IoT technology connected to the internet but instead uses a local network for data transmission and monitoring. With this approach, data from wearable devices is sent directly to a local Raspberry Pi-based server via a local Wi-Fi connection, making it more secure, stable, and independent of cloud services. This test is conducted to assess heart health based on the BPM values generated by the system

Table 2. Heart Health Test Results

NO	Gender	Age	BPM	Status	LED
1	Male	23	102	Tachycardia	Red
2	Female	48	74	Normal	Green
3	Male	57	85	Normal	Green
4	Female	86	58	Bradycardia	Yellow
5	Male	34	79	Normal	Green
6	Male	14	79	Normal	Green

.

Based on the test results, a BPM classification analysis was conducted on six participants with different ages and genders. Each participant underwent ten repeated measurements, and the BPM values presented in Table 2 represent the average values obtained from the ten measurements. The resulting BPM values were classified into three predefined categories: Normal, Tachycardia, and Bradycardia. The system also provided a visual LED indicator corresponding to each classification category.

The results showed that four participants were classified as Normal, with average BPM values ranging from 74 to 85 BPM. The system activated the green LED indicator for these participants. The normal results were obtained from a 48-year-old female with an average BPM of 74 BPM, a 57-year-old male with 85 BPM, a 34-year-old male with 79 BPM, and a 14-year-old male with 79 BPM.

One participant was classified as Tachycardia. The 23-year-old male participant recorded an average BPM of 102 BPM, resulting in the activation of the red LED indicator. The measurement was performed after the participant had engaged in strenuous physical activity, which may have contributed to the elevated heart rate. Meanwhile, the 86-year-old female participant recorded an average BPM of 58 BPM and was classified as Bradycardia based on the predefined classification criteria. The system consequently activated the yellow LED indicator.

Overall, the results demonstrate that the developed system was able to acquire BPM values from six participants, calculate the average BPM from ten repeated measurements, and classify the resulting values according to the predefined heart rate categories. The corresponding green, red, and yellow LED indicators were activated consistently with the classification results. These findings demonstrate that the BPM classification and visual indication functions of the developed system operated according to the specified criteria.

3.3 Data Transmission Testing

This test was conducted to evaluate the data transmission performance of the developed system based on Packet Loss Rate (PLR) and latency parameters. The test was performed by varying the data transmission interval to determine its effect on the number of transmitted and lost packets. The Packet Loss Rate (PLR) was calculated based on the total number of packets transmitted and the number of packets lost during each test condition. The following equations were used:

a) Packet Loss Rate

$$PLR = \frac{Nloss}{Ntotal}\, x\, 100\% \qquad (3)$$

Table 3. Packet Loss

Times	Data Sent	Data Received	Loss	Device
250ms	7,344	7,298	0,62%	Esp8266
500ms	3,463	3,463	0%	Esp8266
750ms	2,229	2,229	0%	Esp8266
1000ms	1,897	1,873	1,2%	Esp8266
250ms	7,776	7,689	1,1%	Esp32C3Supermini
500ms	3,673	3,656	0,4%	Esp32C3Supermini
750ms	2,457	2,407	2%	Esp32C3Supermini
1000ms	1,967	1,957	0,5%	Esp32C3Supermini

The ESP32-C3 Super Mini was included as a comparison device to provide a reference for evaluating the packet transmission performance of the ESP8266. Based on the test results, the ESP32-C3 Super Mini produced packet loss rates of 1.1%, 0.4%, 2.0%, and 0.5% at transmission intervals of 250 ms, 500 ms, 750 ms, and 1000 ms, respectively. Meanwhile, the ESP8266 recorded packet loss rates of 0.62%, 0%, 0%, and 1.2% at the same intervals. Although both devices demonstrated relatively low packet loss, the ESP8266 showed more consistent performance at the 500 ms and 750 ms intervals. Therefore, the ESP32-C3 Super Mini results serve primarily as a comparative reference, while the ESP8266 was retained as the main microcontroller in the proposed system.

.

3.4 Local Server Testing

←T→				id	timestamp	ecg_value	device_id	bpm	status
	Edit	Copy	Delete	1051	2026-07-27 14:45:15	220	ecg_user01	65	Normal
	Edit	Copy	Delete	1050	2026-07-27 14:45:11	702	ecg_user01	45	Bradikardia
	Edit	Copy	Delete	1049	2026-07-27 14:45:10	310	ecg_user01	53	Bradikardia
	Edit	Copy	Delete	1048	2026-07-27 14:45:09	847	ecg_user01	53	Bradikardia
	Edit	Copy	Delete	1047	2026-07-27 14:45:07	561	ecg_user01	65	Normal
	Edit	Copy	Delete	1046	2026-07-27 14:45:06	597	ecg_user01	64	Normal
	Edit	Copy	Delete	1045	2026-07-27 14:45:05	256	ecg_user01	68	Normal
	Edit	Copy	Delete	1044	2026-07-27 14:45:04	540	ecg_user01	61	Normal
	Edit	Copy	Delete	1043	2026-07-27 14:45:03	261	ecg_user01	87	Normal
	Edit	Copy	Delete	1042	2026-07-27 14:45:02	198	ecg_user01	71	Normal
	Edit	Copy	Delete	1041	2026-07-27 14:45:01	778	ecg_user01	77	Normal
	Edit	Copy	Delete	1040	2026-07-27 14:45:00	673	ecg_user01	70	Normal
	Edit	Copy	Delete	1039	2026-07-27 14:44:58	523	ecg_user01	73	Normal
	Edit	Copy	Delete	1038	2026-07-27 14:44:57	558	ecg_user01	68	Normal
	Edit	Copy	Delete	1037	2026-07-27 14:44:56	309	ecg_user01	67	Normal
	Edit	Copy	Delete	1036	2026-07-27 14:44:55	368	ecg_user01	64	Normal
	Edit	Copy	Delete	1035	2026-07-27 14:44:54	388	ecg_user01	63	Normal
	Edit	Copy	Delete	1034	2026-07-27 14:44:53	760	ecg_user01	59	Bradikardia

Figure 6. Local server Web View

Based on the results of data storage testing on the Raspberry Pi server, the system successfully received and stored sensor readings in real time into a MySQL database via phpMyAdmin. The stored data includes the transmission time, ECG values, BPM values, and heart rate status. Each data entry has a unique timestamp, indicating that the logging process is sequential and automatic.

Test results show that the Raspberry Pi, acting as a local server, functions effectively as a data storage hub. The received BPM values were also successfully classified into heart health categories, such as Normal and Tachycardia. This demonstrates that the data transmission process from the microcontroller to the server is functioning properly, and that the database is capable of storing ECG monitoring data in a structured and consistent manner.

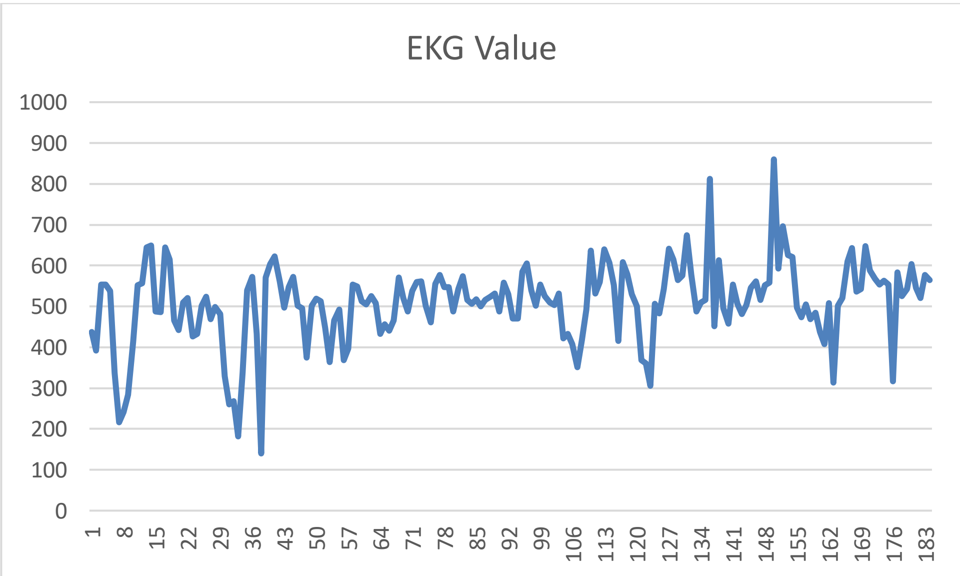

Figure 7. ECG Value Graph

Figure 7 presents the ECG values recorded by the developed monitoring system during the testing process. The recorded values show a fluctuating pattern throughout the measurement sequence, with most readings distributed approximately between 400 and 600. Several higher and lower values can also be observed at different measurement points. The highest observed values are approximately 820–850, while some readings decrease to approximately 150–200. These variations indicate changes in the electrical signal acquired by the AD8232 sensor during the measurement process.

The fluctuation in the recorded values may be influenced by variations in the acquired ECG signal and measurement conditions, including electrode contact, body movement, and electrical interference. Therefore, the graph is presented to describe the behavior and variation of the sensor output during data acquisition rather than to determine clinical ECG characteristics. The results demonstrate that the developed system was able to continuously acquire and record ECG-related signal values throughout the testing process.

4. CONCLUSION

This study successfully designed and implemented a prototype of a Raspberry Pi-based local network wearable cardiac health monitoring system as a self-contained cardiovascular monitoring solution. The developed system integrates an AD8232 ECG sensor, an ESP8266 microcontroller, and a Raspberry Pi as a local server for ECG data acquisition, transmission, display, and storage without relying on a public internet connection. Testing involving six participants demonstrated an average accuracy of 97.75% with an average error of 2.25% compared with a pulse oximeter as the reference device. The system also successfully classified heart rate conditions into three categories: normal, bradycardia, and tachycardia. In terms of data transmission, the ESP8266 achieved 0% packet loss at transmission intervals of 500–750 ms, while the Raspberry Pi successfully stored ECG, BPM, and timestamp data in a structured manner. Overall, the prototype demonstrated the feasibility of local ECG data acquisition, transmission, monitoring, and structured storage within a local network environment. However, clinical validity, long-term reliability, cost-effectiveness, and the capability of the system for clinical cardiovascular screening were not evaluated in this study. Therefore, the findings are limited to the functional performance demonstrated by the developed prototype. Further research involving larger participant samples, clinical evaluation using validated reference devices, security assessment, and long-term reliability testing is required to further validate the system.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

REFERENCES

[1] G. Prieto-Avalos, N. A. Cruz-Ramos, G. Alor-Hernández, J. L. Sánchez-Cervantes, L. Rodríguez-Mazahua, and L. R. Guarneros-Nolasco, "Wearable Devices for Physical Monitoring of Heart: A Review," May 01, 2022, *MDPI*. doi: 10.3390/bios12050292.

[2] J. D. Huang, J. Wang, E. Ramsey, G. Leavey, T. J. A. Chico, and J. Condell, "Applying Artificial Intelligence to Wearable Sensor Data to Diagnose and Predict Cardiovascular Disease: A Review," *Sensors*, vol. 22, no. 20, Oct. 2022, doi: 10.3390/s22208002.

[3] M. I. Saputra, M. M. Robih, and J. Juhaeriyah, "Design and Development of Heart Vest for Heart health Monitoring Based on Internet of Things (IoT)," vol. 4, no. 10, 2025, doi: 10.58344/jws.v4i10.1525.

[4] M. Moshawrab, M. Adda, A. Bouzouane, H. Ibrahim, and A. Raad, "Smart Wearables for the Detection of Cardiovascular Diseases: A Systematic Literature Review," Jan. 01, 2023, *MDPI*. doi: 10.3390/s23020828.

[5] L. Neri *et al.*, "Electrocardiogram Monitoring Wearable Devices and Artificial-Intelligence-Enabled Diagnostic Capabilities: A Review," May 01, 2023, *MDPI*. doi: 10.3390/s23104805.

[6] X. Zhang, Y. Zhan, X. Wang, and J. Yang, "A Chest Strap-Based System for Electrocardiogram Monitoring," *Applied Sciences (Switzerland)*, vol. 15, no. 11, Jun. 2025, doi: 10.3390/app15115920.

[7] A. B. Nigusse, D. A. Mengistie, B. Malengier, G. B. Tseghai, and L. Van Langenhove, "Wearable smart textiles for long-term electrocardiography monitoring—a review," *Sensors*, vol. 21, no. 12, Jun. 2021, doi: 10.3390/s21124174.

[8] E. S. Dahiya, A. M. Kalra, A. Lowe, and G. Anand, "Wearable Technology for Monitoring Electrocardiograms (ECGs) in Adults: A Scoping Review," Feb. 01, 2024, *Multidisciplinary Digital Publishing Institute (MDPI)*. doi: 10.3390/s24041318.

[9] F. Li, H. Tang, S. Shang, K. Mathiak, and F. Cong, "Classification of heart sounds using convolutional neural network," *Applied Sciences (Switzerland)*, vol. 10, no. 11, Jun. 2020, doi: 10.3390/app10113956.

[10] A. Rancea, I. Anghel, and T. Cioara, "Edge Computing in Healthcare: Innovations, Opportunities, and Challenges," Sep. 01, 2024, *Multidisciplinary Digital Publishing Institute (MDPI)*. doi: 10.3390/fi16090329.

[11] Y. Ansari, O. Mourad, K. Qaraqe, and E. Serpedin, "Deep learning for ECG Arrhythmia detection and classification: an overview of progress for period 2017–2023," 2023, *Frontiers Media SA*. doi: 10.3389/fphys.2023.1246746.

[12] Y. M. Obeidat and A. M. Alqudah, "An Embedded System Based on Raspberry Pi for Effective Electrocardiogram Monitoring," *Applied Sciences (Switzerland)*, vol. 13, no. 14, Jul. 2023, doi: 10.3390/app13148273.

[13] A. B. Nigusse, B. Malengier, and L. Van Langenhove, "Development and Evaluation of a Wearable ECG Monitoring System †," *Engineering Proceedings*, vol. 52, no. 1, 2024, doi: 10.3390/engproc2023052009.

[14] Z. Alimbayeva, C. Alimbayev, K. Ozhikenov, N. Bayanbay, and A. Ozhikenova, "Wearable ECG Device and Machine Learning for Heart Monitoring," *Sensors*, vol. 24, no. 13, Jul. 2024, doi: 10.3390/s24134201.

[15] K. Sharma and R. Eskicioglu, "DEEP LEARNING-BASED ECG CLASSIFICATION ON RASPBERRY PI USING A TENSORFLOWLITE MODEL BASED ON PTB-XL DATASET," *International Journal of Artificial Intelligence and Applications (IJAIA)*, vol. 13, no. 4, 2022, doi: 10.5121/ijaia.2022.1340455.

[16] X. Huai, L. Jiang, C. Wang, P. Chen, and H. Li, "Heart sound classification based on convolutional neural network with convolutional block attention module," *Front. Physiol.*, vol. 16, 2025, doi: 10.3389/fphys.2025.1596150.

[17] M. D. Nguyen *et al.*, "A Comparative Study of Wi-Fi Technologies in Wireless Sensor Networks," *Computer Networks and Communications*, pp. 75–87, Feb. 2025, doi: 10.37256/cnc.3120256070.

[18] S. Ghousia Begum, E. Priyadarshi, S. Pratap, S. Kulshrestha, and V. Singh, "Automated Detection of Abnormalities in ECG signals using Deep Neural Network," *Biomedical Engineering Advances*, vol. 5, p. 100066, Jun. 2023, doi: 10.1016/j.bea.2022.100066.

.

[19] R. Dhuny, A. A. I. Peer, N. A. Mohamudally, and N. Nissanke, “Performance evaluation of a portable single-board computer as a 3-tiered LAMP stack under 32-bit and 64-bit Operating Systems,” *Array*, vol. 15, Sep. 2022, doi: 10.1016/j.array.2022.100196.

[20] M. Alghieth, “DeepECG-Net: a hybrid transformer-based deep learning model for real-time ECG anomaly detection,” *Sci. Rep.*, vol. 15, no. 1, Dec. 2025, doi: 10.1038/s41598-025-07781-1.

[21] M. Akter, N. Islam, A. Ahad, M. A. Chowdhury, F. F. Apurba, and R. Khan, “An Embedded System for Real-Time Atrial Fibrillation Diagnosis Using a Multimodal Approach to ECG Data,” *Eng*, vol. 5, no. 4, pp. 2728–2751, Dec. 2024, doi: 10.3390/eng5040143.

[22] V. Randazzo, J. Ferretti, and E. Pasero, “Anytime ecg monitoring through the use of a low-cost, user-friendly, wearable device,” *Sensors*, vol. 21, no. 18, Sep. 2021, doi: 10.3390/s21186036.

[23] Z. Wu and C. Guo, “Deep learning and electrocardiography: systematic review of current techniques in cardiovascular disease diagnosis and management,” Dec. 01, 2025, *BioMed Central Ltd*. doi: 10.1186/s12938-025-01349-w.

[24] A. Mukhopadhyay, A. Remanidevi Devidas, V. P. Rangan, and M. V. Ramesh, “A QoS-Aware IoT Edge Network for Mobile Telemedicine Enabling In-Transit Monitoring of Emergency Patients,” *Future Internet*, vol. 16, no. 2, Feb. 2024, doi: 10.3390/fi16020052.

[25] A. A. Fadhel and H. M. Hasan, “Reducing Delay and Packets Loss in IoT-Cloud Based ECG Monitoring by Gaussian Modeling,” *International journal of online and biomedical engineering*, vol. 19, no. 6, pp. 97–113, 2023, doi: 10.3991/ijoe.v19i06.38581.

BIOGRAPHIES OF AUTHORS

Alamul Iman is an Electrical Engineering undergraduate at Universitas Swadaya Gunung Jati, Cirebon, with strong interests in electrical maintenance, instrumentation, industrial control systems, robotics, and HVAC. In addition to his academic pursuits, he has gained practical technical experience through internships in the telecommunications, manufacturing, and HVAC sectors, including work related to preventive maintenance, electrical panel assembly, PLC-based control systems, and equipment troubleshooting. He has also served as a robotics instructor, where he taught microcontroller programming, sensor applications, robot assembly, and line follower robot development. His professional interests focus on the practical applications of electrical engineering, particularly in maintenance systems, PLC/SCADA, embedded systems, robotics, and improving system reliability and efficiency. He can be contacted at email: alamul.324220001@ugj.ac.id

Juju Juhaeriyah is a lecturer and researcher in the Department of Electrical Engineering at Universitas Swadaya Gunung Jati (UGJ), Indonesia. She earned both her Bachelor's and Master's degrees in Electrical Engineering from Bandung Institute of Technology (ITB). Her academic and research interests include the Internet of Things (IoT), intelligent control systems, fuzzy logic, embedded systems, smart healthcare technologies, environmental monitoring, automation, and smart agriculture. Her research focuses on developing practical and intelligent monitoring and control solutions that integrate sensors, microcontrollers, wireless communication, and artificial intelligence techniques. Among her notable publications are studies on IoT-based health monitoring systems, smart security systems, wastewater monitoring platforms, wearable heart-health monitoring devices, and comparative analyses of Sugeno and Tsukamoto fuzzy logic methods for temperature control applications. She has actively participated in research and development projects involving real-time monitoring, intelligent sensing, and IoT-enabled automation systems for healthcare, environmental management, and industrial applications. Through her teaching, research, and community engagement activities, she continues to contribute to the advancement of Electrical Engineering, particularly in the fields of IoT, embedded intelligence, smart monitoring systems, and adaptive control technologies. He can be contacted at email: juju.juhaeriyah@ugj.ac.id