Proceeding of International Joint Conference on UNESA
Homepage : https://proceeding.unesa.ac.id/index.php/pijcu
e-ISSN : 3032 - 3762

PIJCU, Vol. 3, No. 1, Desember 2025
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Design of a Heart Rate and Blood Pressure Monitoring System Using Telegram with an LM2596 Input Voltage Module

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Keywords:
Blood pressure
Pulse rate
MPX5050GP Sensor
MAX30100 Sensor
Health monitoring

ABSTRACT

Public health is a collective effort to improve quality of life through disease prevention and promotion of healthy lifestyles. One of the important indicators in maintaining health is blood pressure and pulse rate, as both are closely related to the risk of diseases such as hypertension. This research aims to design a sensor-based health monitoring system that can measure blood pressure using the MPX5050GP sensor and pulse rate with the MAX30100 sensor. The system is also equipped with a buzzer as a warning and a remote data transmission feature via Telegram. The method used is experimental, by comparing the sensor results against standard tools (tensimeter and oximeter) to obtain the percentage error and analyze its feasibility. Results show that the MAX30100 sensor has a low error, between 1,40% to 2,01%, with an average of 1,69% against the pulse oximeter, demonstrating its reliability for real-time pulse monitoring in non-clinical applications. The MPX5050GP sensor also demonstrated high accuracy with systolic error between 0,60% to 2,8% and diastolic between 1,51% to 2,54% against the digital tensimeter. These findings prove that both sensors are feasible to use for personal health monitoring systems. It is hoped that this system can help individuals with unstable health conditions and increase public awareness in controlling health conditions independently and sustainably.

INTRODUCTION

Public health is a branch of science and practice that aims to maintain, protect, and improve the health status of a population through promotive, preventive, curative, and rehabilitative approaches (Farid, 2025). Two important parameters that are often used to assess the condition of the cardiovascular system are blood pressure and pulse rate. According to (Kurniawati et al., 2024), these two indicators are fluctuating and can change at any time, necessitating consistent monitoring. Regular blood pressure monitoring is crucial in detecting hypertension early, enabling faster medical intervention before more serious complications arise. Similarly, a pulse rate outside the normal range may indicate heart or blood vessel issues, particularly in the elderly and individuals with a history of heart disease. With advances in technology, remote health monitoring solutions that can be integrated with smartphones are now available. In this study, the monitoring system uses the Telegram application because of its ease in automatically sending messages containing blood pressure and pulse rate measurements (Mubarok and Sunarto 2024). To ensure power stability during system operation, an LM2596 module is used as a step-down converter, which is crucial for the microcontroller device to operate optimally without being disrupted by voltage fluctuations (Jundullah et al., 2025). With this system design, it is hoped that users can become more aware of their health condition in real-time and take preventive measures early on to reduce the risk of more serious health complications.

RESEARCH METHOD

This chapter will discuss several stages, such as describing the research flowchart and the tool's work system flowchart, designing software and hardware, designing the components to be used, and designing the tool's cable system.

1.1 Research Steps

In designing a device for monitoring blood pressure and pulse rate, this study went through several systematic stages that were designed in a structured manner. The series of stages can be seen in Figure 1 in the form of the following flowchart.

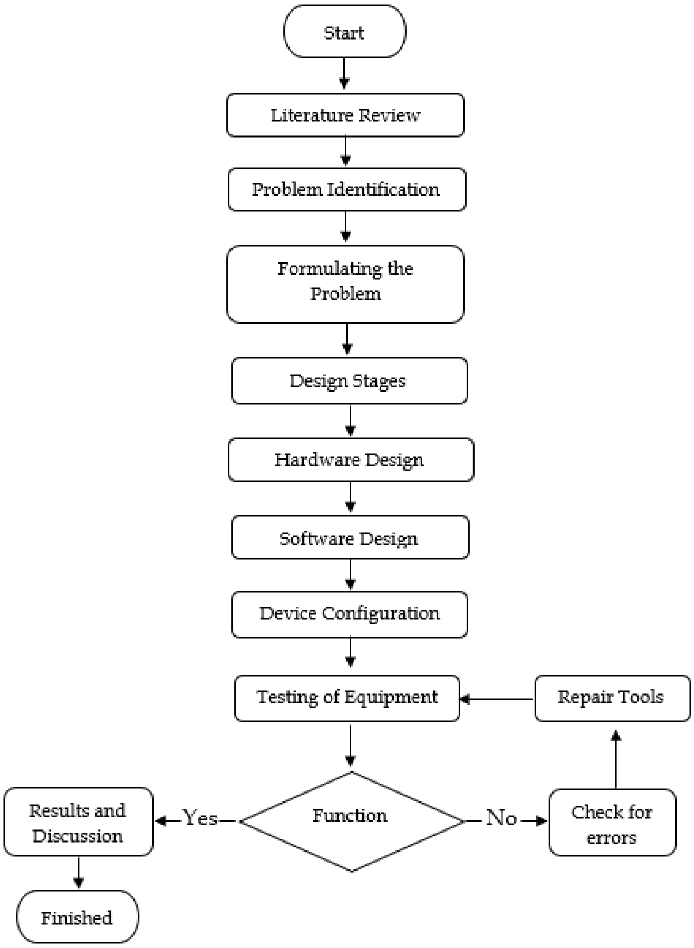

Figure 1. Research Flow Chart
Source : Personal Documents

The explanation of the flow or stages in the research diagram is presented as follows:

1. This stage involves reviewing literature through journals, books, and final projects relevant to the research topic.
2. Problem identification is carried out to set boundaries and focus the direction of research more precisely.
3. The next step is to design the hardware and software components.
4. The tools are set up to ensure that each component functions properly.
5. Conducting equipment trials and documenting measurement data.

6. The final step is to design a final report based on the research results.

1.2 Creating A Device Design Diagram

At this stage, the flow rate of the components used is determined. Figure 2 below shows the tool path diagram designed in the system planning stage.

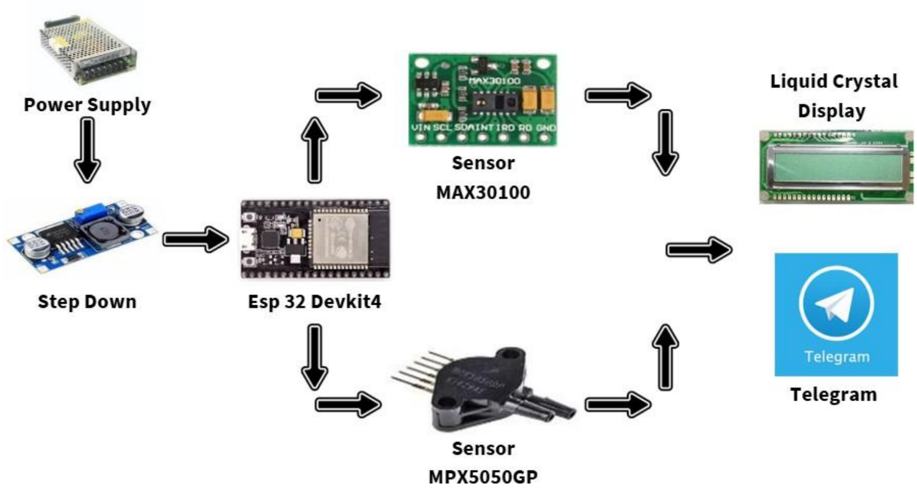

Figure 2 system planning stage
Source : Personal Documents

In this scheme, the electrical power source with an input voltage of 12V is stepped down using an LM2596 step-down module to produce 5V and 3.3V voltages, which are used to power the ESP32. The ESP32 is then connected to the MPX5050GP sensor, MAX30100 sensor, Liquid Crystal Display (LCD), and other components. while the air pump and solenoid valve are controlled via the L298N driver module, which regulates the pumping process in the cuff system (Alfisyahri 2024).

1.3 System Work Stages

The first step in creating this device is to set the lower and upper limits for each sensor used. Once these limits have been set, the next step is to program these parameters into the system and integrate them into the device. The measurement process is carried out with the user lying down, with a blood pressure cuff on the left arm and a finger on the pulse sensor. The measurement results are displayed on the LCD screen and automatically sent via the Telegram bot application. The system is also equipped with a buzzer and a feature to send repeated messages (spam) to the Telegram bot as a notification when the sensor data is below or above the specified threshold.

1.4 Microcontroller Design Diagram

The main power source used to supply power to the L298N motor controller is 12V (Handson Technology 2022). Additionally, this power source is also used to supply voltage to various components such as the ESP32 microcontroller (Umar, Nur, and Imron 2022), the MPX5050GP sensor (Sujiwa 2023), the MAX30100 sensor (EasyEDA, 2024), and the liquid crystal display (Andreyanto et al. 2019). To meet the specific requirements of each device, the 12V voltage from the power supply is first stepped down using the LM2596 voltage regulator module (Akin-Ponnle & Ponnle, 2024), producing 5V and 3.3V outputs. The 5V voltage is used for components such as the LCD and pressure sensor, while the 3.3V voltage is used for the ESP32 microcontroller and MAX30100 pulse sensor. As shown in Figure 3.

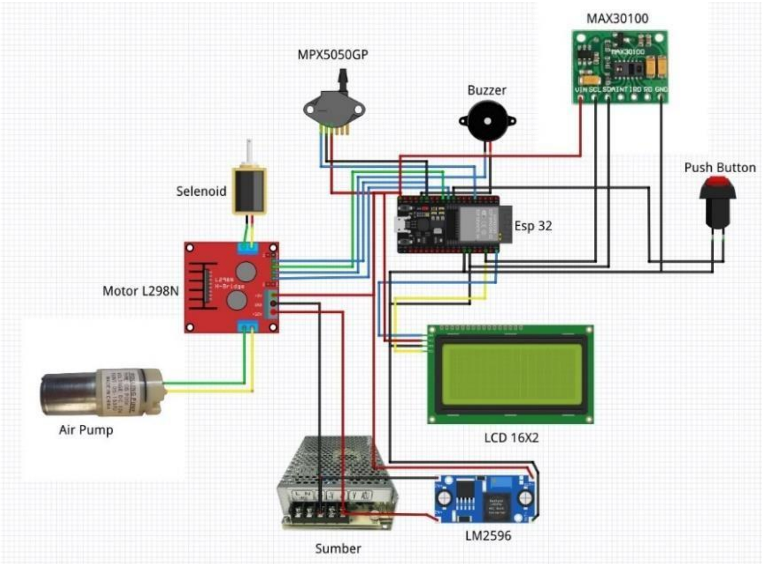

Figure 3 Microcontroller Design Diagram
Source : Personal Documents

RESULTS AND DISCUSSION

This study aims to ensure that the pulse sensor and blood pressure sensor can function optimally when integrated with the designed device. In addition, this study also includes a feature for remote transmission of measurement results via the Telegram application. It is hoped that the system developed in this study can provide benefits, especially for individuals with a history of blood pressure and heart rate disorders, thereby facilitating independent health monitoring.

1.5 Results of the tool design

The results of the tool design can be seen in Figure 4, where all system components are placed inside a black box (box) of type X7. This box has dimensions of 21.5 cm in length, 14.5 cm in width, and 8.5 cm in height, designed to neatly and safely accommodate the entire electronic circuitry.

Figure 4 Results of the tool design
Source : Personal Documents

1.6 Software Results That Have Been Designed

Programming on this system is done using Arduino IDE (Integrated Development Environment), which is a built-in application from the Arduino platform specifically designed to program and control open-source single-board microcontrollers (Nizam et al., 2022). The result of this software design is integration with a Telegram bot, where the Telegram application is used as a communication medium to receive and display data from blood pressure and heart rate monitoring devices (Rahmawarni and Harmadi 2021). Through this bot, users can view real-time blood pressure and heart rate information in the form of messages sent directly to the Telegram application (Luthfiyah and Widajati 2019)(Zaki and Anifah 2023) in Figure 5.

Figure 5. Telegram bot display
Source : Personal Documents

1.7 Comparison of MPX5050GP sensor measurement results with digital tensiometer

This test was conducted to determine the accuracy of the device when used in real conditions. Based on the test results in Table 1, measurement data was obtained using the MPX5050GP sensor and compared with the results from a digital tensiometer as a reference device.

Tabel 1 Blood Pressure Measurement Results for Subjects Aged 11–20 Years

No	Age	MPX5050GP Sensor (mmHg)		Tensimeter TensiOne (mmHg)		Percentage error (%)	
		Systole	Diastole	Systole	Diastole	Systole	Diastole
1	20 years	125	77	127	79	1,57	2,53
2	20 years	122	81	123	79	0,81	2,53
3	20 years	121	76	120	75	0,83	1,33
4	20 years	124	79	125	78	0,8	1,28
5	20 years	126	77	124	79	1,61	2,53
Average *Error*						1,12	2,04

Source : Personal Documents

1.8 Comparison of MAX30100 sensor measurement results with Pulse Oximeter

This test was conducted to determine the accuracy of the device when used in real conditions. Based on the test results in Table 2, measurement data was obtained using the MAX30100 sensor and compared with the results from the Pulse Oximeter as a reference device.

Tabel 2 Pulse Measurement Results for Subjects Aged 11–20 Years

No	Age	MAX 30100 Sensor (bpm)	Pulse Oximeter (bpm)	Difference	Percentage error (%)
1	20 years	98	96	2	2,08
2	20 years	97	96	1	1,04
3	20 years	93	95	2	2,11
4	20 years	96	94	2	2,13
5	20 years	95	96	1	1,04
Average error (%)					1,68

1.9 Explanation of results through graphs

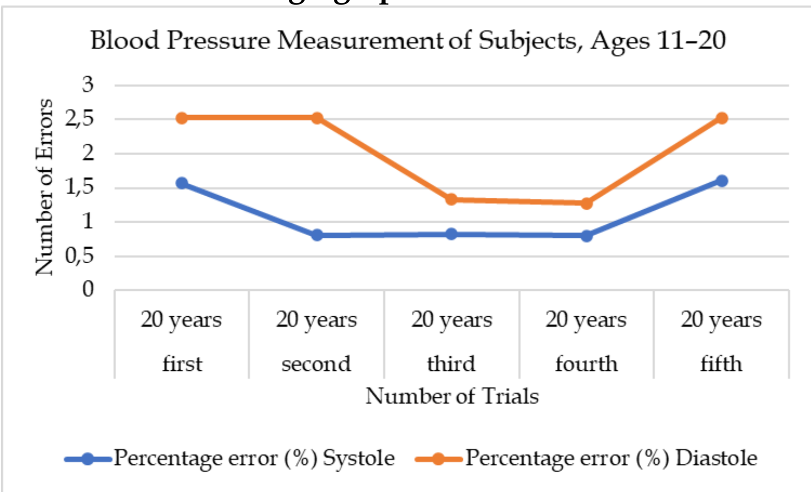

Figure 6 Graph of Blood Pressure Measurement Results in Subjects Aged 11–20 Years
Source : Personal Documents

The results shown in Figure 6 indicate that the average systolic pressure obtained from the MPX5050GP sensor is 123.6 mmHg, while the average diastolic pressure reaches 78 mmHg. Based on the graph, there is a difference between the measurement results using the MPX5050GP sensor and the digital tensiometer. For systolic pressure, the measurement difference ranges from 0.8% to 1.61%, with an average difference of 1.12%. Meanwhile, for diastolic pressure, the difference ranged from 1.28 to 2.53%, with an average of 2.04%. Overall, this data indicates that the system has a sufficiently high level of accuracy and reliability in measuring blood pressure, particularly for the first subject within the age range of 11 to 20 years.

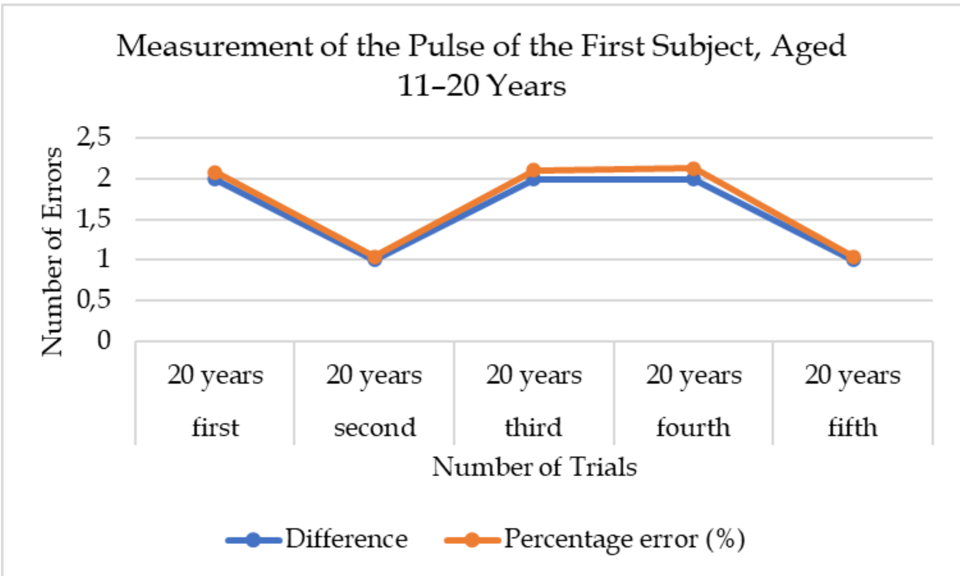

Figure 7 Graph of Pulse Measurement Results for Subjects Aged 11–20 Years
Source : Personal Documents

The results shown in Figure 7 indicate that the average heart rate obtained from the MAX30100 sensor is 95.8 bpm. Based on the graph, there is a difference between the measurement results of the MAX30100 sensor and the reference device, which is a pulse oximeter. The difference in measurement values ranges from 1 to 2 bpm, with an error percentage ranging from 1.04% to 2.13%, and an average error of 1.68%. Overall, this data indicates that the system is capable of providing sufficiently accurate and reliable results in measuring heart rate, particularly for the first subject within the age range of 11 to 20 years.

CONCLUSION

Based on the research entitled "Designing a Heart Rate and Blood Pressure Monitoring System Using Telegram with an LM2596 Input Voltage Module," which aims to support health improvement by providing heart rate and blood pressure monitoring devices, especially for individuals with frequently unstable health conditions, it can be concluded that :

1. The MAX30100 sensor used to measure heart rate showed a low average error percentage across all age groups, ranging from 1.40% to 2.01%, with an overall average of approximately 1.69% when compared to a pulse oximeter. These error values demonstrate that the MAX30100 sensor is suitable for use as a digital, real-time heart rate monitoring device for non-clinical applications.
2. The MPX5050GP sensor used to measure blood pressure also demonstrates a high level of accuracy. The average systolic pressure error ranges from 0.60% to 2.8%, while diastolic pressure ranges from 1.51% to 2.54%, when compared to a standard digital tensiometer. These results indicate that the MPX5050GP sensor is suitable for use in blood pressure monitoring systems, particularly in the context of personal or non-clinical monitoring.

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