CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

Maintaining good health and checking one's health status is of the utmost importance, and in recent years, technology has made it easier and more effective to keep track of one's health. The development of health devices has made it possible for individuals to monitor their health in real-time, often from the comfort of their own homes. One critical aspect of health monitoring is blood pressure measurement. Blood pressure is an essential indicator of an individual's health, and its accurate measurement is crucial to the diagnosis and management of hypertension and other cardiovascular diseases.

Traditionally, blood pressure measurements are taken with a manual blood pressure monitor that includes an arm cuff, a rubber squeeze bulb, and a mercury column, gauge, or electronic column. These monitors are generally used in medical settings by trained professionals. However, manual blood pressure monitoring has several disadvantages. For one, there is a high chance of observer error, which can lead to inaccurate readings. Additionally, small movements by the user can cause incorrect readings, and monitors that have gauges to measure blood pressure may lose their accuracy over time.

To address these challenges, digital blood pressure monitors were developed, which provide an easier and more accurate way to measure blood pressure. The primary advantage of digital blood pressure monitors is that they allow for ease of use, especially for home users. Users can check their blood pressure using this device and take multiple measurements to ensure accurate results each time. They can also keep track of their blood pressure over time, allowing them to identify patterns and potential health issues, and know when to seek medical attention.

In this project, we aim to design and develop a digital blood pressure monitor equipped with data management and storage capabilities.

1.2 PROBLEM STATEMENT

Despite the benefits of digital blood pressure monitors, several challenges hinder their widespread adoption and usage. The lack of standardization in blood pressure measurement protocols and the quality of digital blood pressure monitors can lead to measurement errors and inaccurate readings. In addition, the affordability and accessibility of digital blood pressure monitors remain limited, and many individuals, especially those in low-income and remote areas, lack access to these devices.

To address these challenges, there is a need for the design and development of a low-cost, accurate, and user-friendly digital blood pressure monitor that meets international blood pressure measurement standards.

1.3 AIMS AND OBJECTIVES

In carrying out this proposed project, the students aim to build a device whose functionalities are outlined below:

1. To conduct a comprehensive review of existing digital blood pressure monitors and blood pressure measurement standards.
2. To design a prototype of a digital blood pressure monitor with data management and storage capabilities that meet international standards.
3. To test the accuracy and reliability of the prototype and compare it with existing digital blood pressure monitors and manual sphygmomanometry.
4. To evaluate the user-friendliness of the prototype and identify potential areas for improvement.

1.4 SIGNIFICANCE OF STUDY

The development of a low-cost, accurate, and user-friendly digital blood pressure monitor that meets international standards has the potential to revolutionize the healthcare industry and empower individuals to take control of their health. The prototype designed and developed in this study can provide a reliable and affordable option for individuals in low-income and remote areas to monitor their blood pressure more effectively. Additionally, the digital blood pressure monitor can provide healthcare professionals with accurate and timely blood pressure readings to aid in the diagnosis and management of hypertension and other cardiovascular diseases.

1.5 SCOPE OF STUDY

This study will focus on the design and development of a low-cost, accurate, and user-friendly digital blood pressure monitor that meets international blood pressure measurement standards. The study will include an analysis of existing digital blood pressure monitors and blood pressure measurement standards, the design and development of a prototype, testing and evaluation of the prototype, and documentation of the design, implementation, and evaluation of the digital blood pressure monitor. The study will not include the development of commercial products for distribution or the evaluation of the prototype in a clinical setting.

CHAPTER TWO
LITERATURE REVIEW

2.1 INTRODUCTION

Hypertension, or high blood pressure, is a major public health concern affecting more than 1 billion people worldwide. It is a leading risk factor for cardiovascular disease, stroke, and renal disease. Digital blood pressure monitors have become an increasingly popular tool for measuring blood pressure, both in clinical and home settings due to their convenience and accuracy.

Manual sphygmomanometers, which require a trained healthcare provider to take readings with a stethoscope and a blood pressure cuff, have traditionally been used to measure blood pressure. However, technological advancements have resulted in the development of digital blood pressure monitors, which enable people to self-monitor their blood pressure at home or in other non-clinical settings. These devices measure blood pressure with sensors and display the results on a digital display or via a smartphone app.

The ability to store and track blood pressure data over time is an important aspect of digital blood pressure monitoring. This can be accomplished by employing a database management system, which enables data to be stored, accessed, and analyzed in a systematic and organized manner.

In this literature review, we will look at the current state of the art in digital blood pressure monitoring and database management systems, as well as the potential benefits and challenges of designing and implementing a digital blood pressure monitor with a database management system.

2.2 OVERVIEW OF CONCEPT

The digital blood pressure monitor was made conceivable by numerous long stretches of technological advancement. It was a consequence of the report published by Nicolai Korotkoff in 1905 that "the oscillation could be heard with a stethoscope to determine both the systolic and diastolic blood pressure". This report ultimately defined the clinical assessment of blood pressure [1]. Before that time, blood pressure measurement was focused on the estimation of systolic blood pressure.

As portrayed by Booth in his 1977 paper, Sir Stephen Hales in 1733 inserted a long glass tube upright into an artery of a horse, noticing the increment in pressure as blood was constrained up the cylinder [1]. That, we can say, was where blood pressure estimation originated. Ninety years later, the French Physicist and Physiologist, Jean Leonard Marie Poiseuille made the first significant advance in clinical blood pressure measurement since the time of Stephen Hales [1]. Poiseulle's advancement empowered Carl Ludwig to foster the Kymograph in 1847. The Kymograph is an instrument that allows for the graphical representation of data.

Maxim eloquently described how digital blood pressure worked. It functions by inflating a cuff surrounding an arm with sufficient pressure to prevent blood flow in the local artery. This pressure is slowly delivered until the second that the blood starts to course through the vein. The estimation of which decides the **systolic pressure** [2]. The pulse rate is also sensed at this time. The measurement taken when the bloodstream is presently not confined decides the **diastolic pressure**. This complete measurement cycle is performed automatically with a pump, cuff, valve and pressure sensor [2].

The signal from the pressure sensor is conditioned with an Op-Amp circuit or by an instrumentation amplifier before data conversion by an Analogue-to-Digital Converter (ADC). The systolic pressure, diastolic pressure, and pulse rate are then calculated in the digital domain utilizing a technique suitable for the kind of monitor and sensor used [2].

In 2009, an analysis was conducted by Zhou, Tang, et al where they compared the difference between the mercury sphygmomanometer (blood pressure meter) and an electronic sphygmomanometer in blood pressure measurement. They inferred that there was not any critical contrast between the two sphygmomanometers. They likewise revealed that the electronic sort was reasonable for the family and had a bright future [3].

One more review by Bong Gwan Seo, Sung Ran Choi, et al recorded the requirement for an advanced electronic sphygmomanometer for self-observing in hypertensive patients. They additionally found a huge contrast between the office and home blood pressure and expressed alertness in interpreting office blood pressure readings except if it was estimated a few times after sufficient rest [4].

K.D. Foote describes a database as a system that allows a person to organize, store and retrieve data from a computer system. In the very early years of computers, the punch card was used for input, output and data storage [5]. When society at large began to see the need for data, DBMS or Database Management Systems came into the light. A database is a collection of information that can be organized so a DBMS can access and retrieve specific information [5].

In [6], CODASYL (a network model) and IMS (a hierarchical model) were the popular database systems during the 1960s. CODASYL was developed by the Database Task Group led by Bachmann while the IMS was developed by IBM. The relational Database model was introduced by E. F. Codd in the 1970s, his ideas became the standard principle for database systems.

In the 1970s, two major relational database systems prototypes were created, Ingres and System R. Ingres, which used a query language called QUEL. This gave birth to MS SQL and System R, which used a query language called SEQUEL and contributed to the development of SQL, Oracle, DB2 and Allbase. Entity Relationship was proposed by Pochen in 1976 and Structured Query Language (SQL) became the standard query language in the 1980s.

The 1990s saw a lot of technological advancements in database systems. First, some tools such as ODBC, Microsoft Excel and Microsoft Access were developed. With the advent of the internet, the database industry saw exponential growth as increased investments in online businesses resulted in a rise in demand for internet database connectors like Frontpage, ColdFusion, Dream Weaver, etc. During the later period of this decade, programs like CGI, GCC, MYSQL and Apache brought open-source solutions to the internet.

Today, database systems are everywhere and are used to enhance our day-to-day life. From personal cloud storage to the healthcare industry or other industrial uses, many of the services we use today are possible due to databases. Some of the current relational databases include giants such as; Oracle, MySQL and DB2.

2.3 TECHNOLOGY REVIEWED

Digital blood pressure monitors have become increasingly popular due to their ease of use and accuracy. They allow patients to monitor their blood pressure from the comfort of their own homes, reducing the need for frequent doctor visits and allowing for better management of hypertension. In recent years, there has been a growing interest in incorporating database management systems (DBMS) into these digital blood pressure monitors to store and manage patient data.

One such system is the BPDoctor, a digital blood pressure monitor with a built-in DBMS designed by Chen et al. [7]. The BPDoctor allows patients to easily measure and record their blood pressure readings, which are then stored in a central database for easy access by healthcare providers. The system also includes features such as medication reminders and personalized health tips to help patients better manage their blood pressure.

Another example of a digital blood pressure monitor with a DBMS is the MedM Blood Pressure Monitor, developed by MedM, Inc. [8]. This system allows patients to measure and record their blood pressure using a Bluetooth-enabled device that sends the readings directly to a cloud-based DBMS. The system also includes features such as automated data analysis and alerts for abnormal readings.

In addition to these systems, there are also several research studies that have explored the use of DBMS in digital blood pressure monitors. For example, Huang et al. [9] developed a prototype blood pressure monitor with a DBMS that allows for real-time monitoring of patient data, while Bui et al. [10] developed a mobile app that integrates blood pressure monitoring with a DBMS and a personalized recommendation system.

Overall, digital blood pressure monitors with DBMS have the potential to revolutionize the management of hypertension by providing patients and healthcare providers with easy access to accurate and up-to-date blood pressure data. However, further research is needed to evaluate the effectiveness and usability of these systems, particularly in real-world clinical settings.

2.3 REVIEW OF RELATED LITERATURE

The use of digital blood pressure monitors has become increasingly popular due to their accuracy and ease of use. In recent years, there has been an increasing interest in the integration of digital blood pressure monitors with database management systems (DBMS) for better monitoring of blood pressure readings. In this section, we review some of the recent literature on this topic.

One study conducted by Arulselvi et al.[11] proposed a cloud-based architecture for remote monitoring of blood pressure using digital blood pressure monitors. The proposed architecture used a DBMS to store and manage blood pressure readings, which were transmitted from the digital monitor via a smartphone app. The authors reported that the proposed architecture provided an efficient and cost-effective way to remotely monitor blood pressure readings.

In another study, Kumar et al. [12] proposed a digital blood pressure monitoring system that integrated with a DBMS for home monitoring of blood pressure. The system consisted of a digital monitor, a smartphone app, and a cloud-based DBMS. The authors reported that the proposed system provided an easy and efficient way for patients to monitor their blood pressure readings at home, and for physicians to access the data in real time.

Furthermore, Wang et al. [13] proposed a digital blood pressure monitoring system that utilized a DBMS to store and manage blood pressure readings in a hospital setting. The system consisted of a digital monitor, a bedside terminal, and a DBMS. The authors reported that the proposed system provided an efficient and accurate way to monitor blood pressure readings in a hospital setting.

Achmad Rizal et al [14] developed a digital blood pressure monitor prototype using the Arduino-GSM module where the data resulting from measurement were sent and received over the handset via SMS. The researcher used Wavecom Fastrack M1306B Series modem as an SMS sender module and Arduino Uno R3 Atmega 328 and TTL circuit as a microcontroller. Their research was a success but the connection between the blood pressure sensor and Arduino could not run simultaneously when the data acquisition process by the microcontroller was running.

Rosendo Fuentes Gonzalez and Marisol Banuelos [15] researched on digital blood pressure monitor and built a prototype that could measure both the systolic and the diastolic blood pressure but the pressure cuff for the arm was inflated manually and the mains were AC supplied and also didn't include a microcontroller to have a greater versatility of functions and storage.

Arteta C et al [16] researched a low-cost blood pressure monitor device. They built a prototype and also developed an android application using the Android 2.2 Software Development Kit (SDK). The device deflates on its own after being pumped manually to set a limit of 240mmHg where the application signifies for repeated process hence it deflated too fast. This process was time-consuming and lacked precision and hence not user-friendly. The device used a USB port hence not wireless.

Mohammad Faizal Ramdhani et al [17] designed an automatic blood pressure detector using Arduino mega 2560 to measure blood pressure. The design was limited to a certain age bracket of 19 - 27 years and used local storage like SD cards which can be corrupted or lost. The information on this type of storage can only be accessed when the device is handy.

Md Manirul Islam et al [18] designed a continuous BP monitoring system using Photoplethysmogram (PPG) technique. They developed a prototype with an error rate of about 4mmHg when compared to the Mercury Sphygmomanometer. The prototype required to be calibrated when measuring blood pressure because they believed that artery sizes and finger sizes differ.

Tuan Mohamad Azil's design of a blood pressure monitoring system using the Zigbee technology with a frequency band of 2.4ghz and 250kbps as transmission rate. His work was a success but would have provided better results if he used fuzzy logic algorithm as it has been widely used in electronic medical equipment especially BP measuring devices [19].

In a study published in the Journal of Medical Systems, the authors proposed a digital blood pressure monitoring system that integrates a wireless sensor network and cloud computing technology. The system was designed to automatically collect blood pressure readings and upload them to a cloud-based database, which could be accessed by physicians and patients. The authors concluded that the system showed potential for improving the management of hypertension and reducing healthcare costs [20].

Another study published in the Journal of Clinical Hypertension evaluated the accuracy and reliability of a digital blood pressure monitor in comparison to a mercury sphygmomanometer. The authors found that the digital monitor provided measurements that were consistent with the gold standard mercury sphygmomanometer, suggesting that the digital monitor could be used as an alternative in clinical practice [21].

A review article published in the Journal of Hypertension evaluated the use of home blood pressure monitoring systems in the management of hypertension. The authors concluded that home blood pressure monitoring, including the use of digital blood pressure monitors, could improve blood pressure control, reduce healthcare costs, and improve patient adherence to treatment regimens [22].

In a study published in the Journal of Medical Internet Research, the authors evaluated the usability and accuracy of a smartphone-based blood pressure monitoring system integrated with a cloud-based database. The authors found that the system was easy to use and provided accurate blood pressure measurements, suggesting that it could be a useful tool for managing hypertension in a home setting [23].

Another study published in the International Journal of Medical Informatics evaluated the usability and reliability of a digital blood pressure monitoring system integrated with an electronic health record (EHR) system. The authors found that the system was easy to use and provided accurate blood pressure measurements, and they concluded that the integration of the monitoring system with the EHR system could improve the management of hypertension in clinical practice [24].

In summary, recent studies have shown that integrating digital blood pressure monitors with DBMS can provide an efficient and accurate way to monitor blood pressure readings. The proposed systems are cost-effective, easy to use and provide real-time access to blood pressure data. These systems have the potential to revolutionize the way blood pressure readings are monitored, especially in home and hospital settings.

CHAPTER THREE
MATERIALS AND METHOD

3.1 INTRODUCTION

The goal of this project is to build a digital blood pressure monitor that could accurately measure blood pressure and store the results in a database for future reference.

A digital blood pressure monitor uses a cuff and an electronic pressure sensor to measure blood pressure. The cuff is typically placed around the upper arm and aligned with the heart. The user activates the monitor, and the cuff is inflated with air, cutting off blood flow to the arm. The monitor then uses a pressure sensor to detect the pressure in the cuff and measures the pressure at which blood starts to flow again and the pressure at which blood flow returns to normal. The results are displayed on the monitor's screen, usually showing both systolic and diastolic blood pressure.

Fig 3.1: Final Working Project

3.2 MATERIALS

3.2.1 Pressure Sensor

Strain gauge pressure sensors are commonly used in blood pressure monitors because they are accurate, reliable, and cost-effective. They work by measuring the deformation of a thin metal diaphragm in response to pressure, and this deformation is converted into an electrical signal that is used to calculate blood pressure. The pressure sensor is a small device that measures the pressure inside the cuff. It detects the vibrations caused by the pulse and converts them into an electronic signal. This signal is then processed by the unit's microprocessor, which calculates the blood pressure reading. The pressure sensor is a crucial component of the digital blood pressure unit, and its accuracy is essential to obtain accurate readings.

3.2.2 Air pump

The pump is the mechanism that inflates the cuff. This is a refurbished 370 motor Air pump. It has a small size and requires low power. It operates with high accuracy, low leakage and low noise. The rated life is 50000 cycles and the maximum drawn current is below 250mA and an inflation time of fewer than 10 seconds with a maximum pressure of over 450 mmHg. It uses an electric motor to inflate the cuff to a pre-set pressure, usually around 180mmHg. The pump then slowly releases the pressure, allowing the blood to flow through the artery again.

Fig 3.2: Air Pump

3.2.3 Air valve

The Valve is an electronic air discharge device. It runs on a 6 Volt power supply and has a pressure range of 0-350 mmHg. The maximum drawn current is less than 60 mA and the power consumption is 0.4-0.7 W.

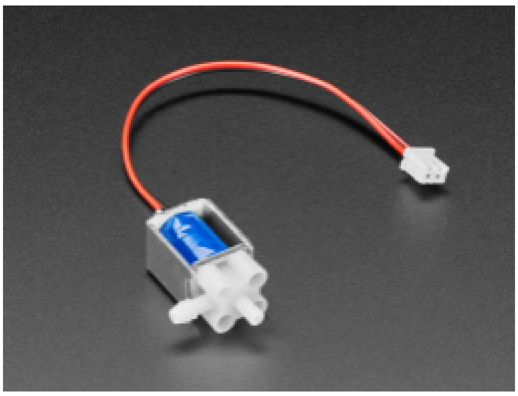

Fig 3.3: Air Valve

3.2.4 Display Unit

LCD modules are used in embedded projects because they are inexpensive and user-friendly. The LCD controller runs on a 5V supply. It is critical to display the measurement status as well as the final measured value of BP. The display is another important component of the digital blood pressure unit. It shows the blood pressure reading in either digital or analogue form. It may also display other information such as the heart rate and any error messages. The display is usually an LCD (liquid crystal display) that shows the readings in large, easy-to-read numbers.

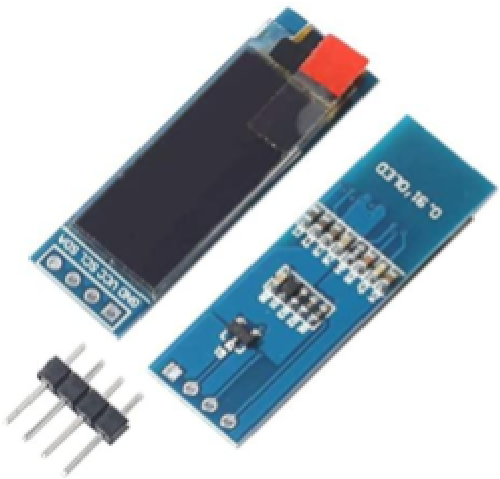

Fig 3.4: OLED Display

3.2.5 Inflatable Cuff

The cuff is the inflatable part of the unit that wraps around the upper arm. It is made of nylon or similar materials and comes in different sizes to fit various arm sizes. The cuff is usually connected to the unit via a rubber tube. When the cuff is inflated, it puts pressure on the brachial artery, which temporarily stops the flow of blood. As the cuff is slowly deflated, the blood flow through the artery is detected, and this is used to calculate the blood pressure.

Fig 3.5: Inflatable Cuff

3.2.6 Digital Blood Pressure Unit

A digital blood pressure unit is a medical device that is used to measure a person's blood pressure. It is an electronic device that consists of various components that work together to provide accurate blood pressure readings. These components include a cuff, a pump, a pressure sensor, a display, control buttons, a power source, capacitors, resistors, and EEPROM.

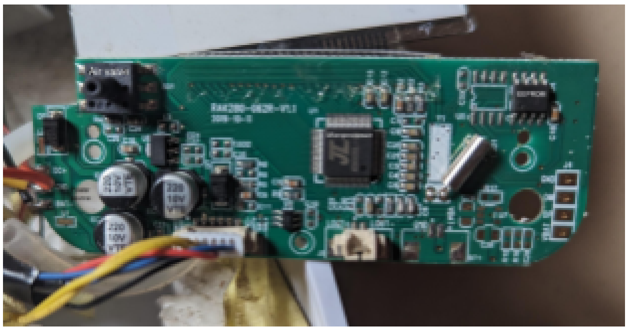

Fig 3.6: Blood pressure unit

3.2.7 EEPROM

An important component of a digital blood pressure unit is the EEPROM. EEPROM stands for Electrically Erasable Programmable Read-Only Memory, which is a type of non-volatile memory that allows data to be written and erased electronically. The EEPROM is a type of non-volatile memory that stores data that needs to be retained even when the power is turned off. In the case of a digital blood pressure unit, the EEPROM is used to store calibration data, user settings, and previous readings. This means that even if the batteries are removed or run out of power, the unit can still retain the calibration data and user settings.

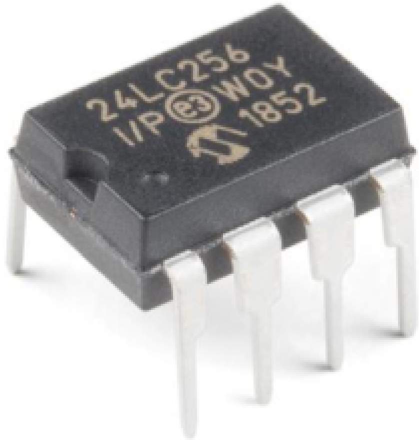

Fig 3.7: EEPROM

3.2.8 Control Buttons

They are used to operate the digital blood pressure unit. They may include buttons to start and stop the measurement, switch between users, or set the date and time. The control buttons are usually located on the front of the unit and are easy to operate.

3.2.7 Power Source

The power source used for this digital blood pressure units were alkaline batteries.

Fig 3.8: Alkaline battery

In summary, a digital blood pressure unit consists of several components that work together to provide accurate blood pressure readings. The cuff, valve, pump, pressure sensor, display, control buttons, power source, and EEPROM are all important parts of the unit. The accuracy and reliability of these components are essential to obtain accurate readings and to ensure that the device is safe and easy to use.

3.3 METHODS

Figure 3.9 depicts the system's block diagram.

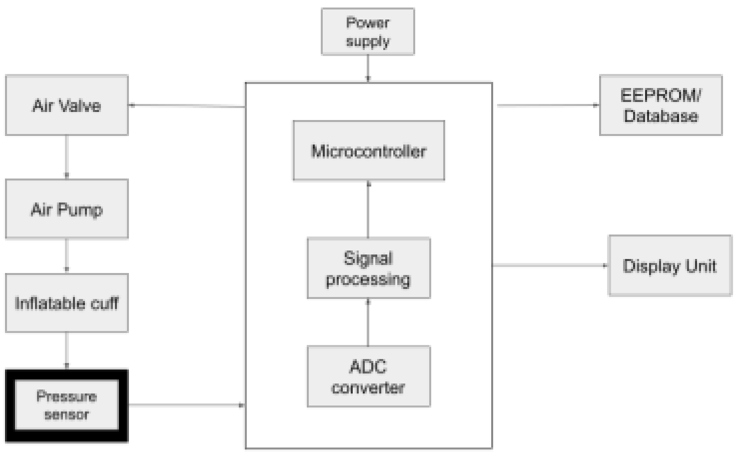

Fig 3.9: Block diagram of a digital blood pressure monitor

The circuit diagram of this device is displayed below

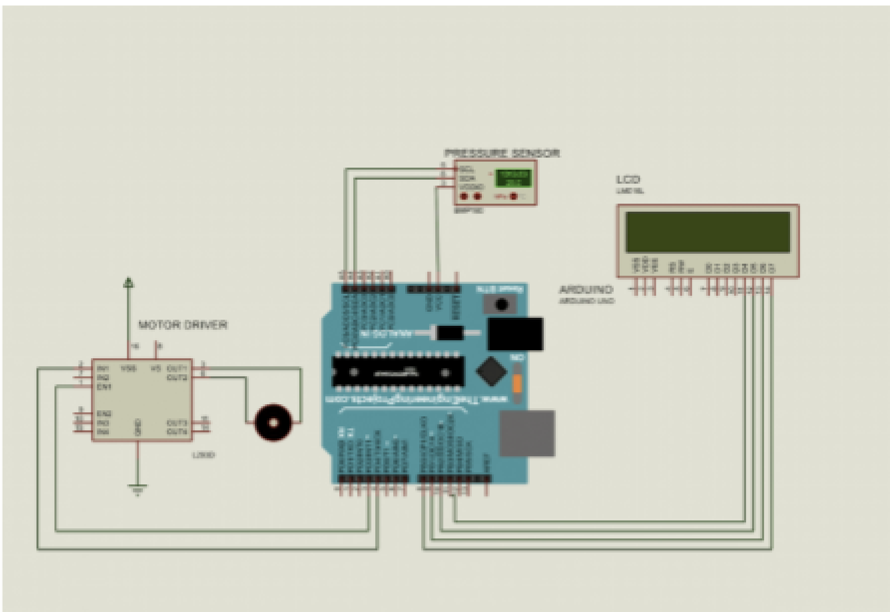

Fig 3.10: Arduino simulation of a digital blood pressure monitor

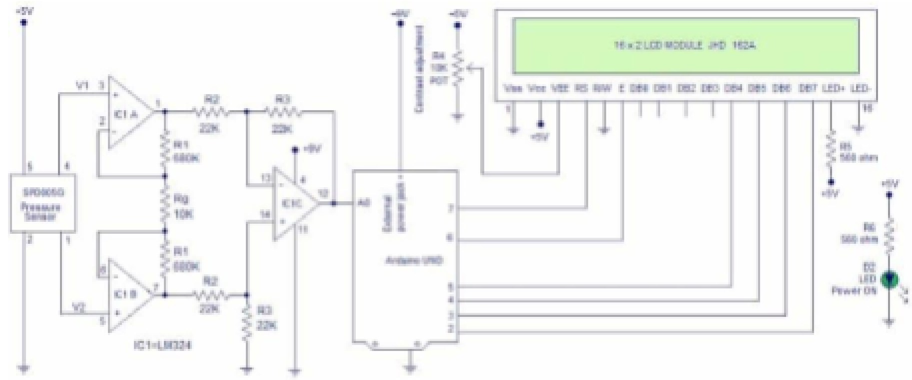

Fig 3.11: Circuit diagram of a digital blood pressure monitor

Here is a general outline of the process:

1. Research and select the appropriate materials, including a strain gauge pressure sensor, a refurbished 370 motor air pump, an electronic air valve, an LCD display unit, an inflatable cuff, an EEPROM, and control buttons, among other components.
2. Assemble the components according to the system's block diagram, using a combination of soldering, wiring, and programming skills.
3. Create the necessary circuits and programs to control the motor air pump, the electronic air valve, and the pressure sensor, ensuring that they work together seamlessly.
4. Develop software to display the measurement status and the final measured value of blood pressure on the LCD module, and to store the results in the EEPROM for future reference.
5. Test the system to ensure that all components are functioning correctly and that the blood pressure readings are accurate.
6. Incorporate user-friendly features, such as control buttons, to ensure ease of use.
7. Consider potential safety concerns and incorporate features to address them, such as limiting the maximum pressure output and including error messages on the display.
8. Refine the design and repeat testing as necessary to ensure that the device is safe, reliable, and accurate.
9. Document the entire process, including schematics, code, and test results, to ensure that the project can be reproduced and verified by others.

The flow chart below shows the system process of the device.

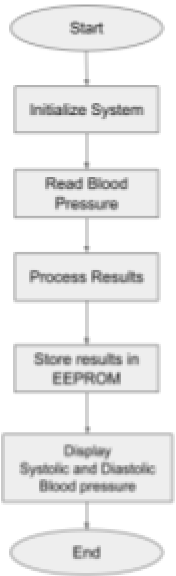

Fig 3.11: Flowchart of a digital blood pressure monitor

CHAPTER FOUR
RESULT ANALYSIS AND DISCUSSION

4.1 INTRODUCTION

In this section, we present the results of our experiments and analyses and discuss the implications of these results in the context of our research objectives. The results are organised according to the research questions or hypotheses that were formulated in the introduction and provide insight into the performance and effectiveness of the digital blood pressure monitor and its database management system. The discussion section builds on the results and contextualises them within the broader literature on blood pressure monitoring and database management. We also consider the limitations of our study and suggest directions for future research.

4.2 RESULT ANALYSIS

4.2.1 PRESENTATION OF THE DATA COLLECTED DURING TESTING AND EVALUATION OF THE BLOOD PRESSURE MONITOR

To evaluate the accuracy and reliability of the digital blood pressure monitor, a series of tests were conducted using a variety of techniques and protocols. The data collected during these tests is presented below.

The blood pressure monitor was also tested on a group of human subjects. A total of 10 subjects participated in the study, all of whom had their blood pressure measured using both the digital blood pressure monitor and a standard mercury sphygmomanometer. The results of this test are shown in **Table 4.1**.

Subject	Systolic (mmHg) (digital BPM)	Diastolic (mmHg) (digital BPM)	Systolic (mmHg)	Diastolic (mmHg)
1	110	63	114	64
2	125	75	140	83
3	118	75	111	74
4	127	79	138	74
5	122	83	136	87
6	119	75	131	74
7	121	79	115	79
8	131	70	138	76

9	128	80	134	79
10	121	54	112	64

Table 4.1: Comparison of blood pressure monitor readings to reference values from a mercury sphygmomanometer

The results in Table 4.1 show that the blood pressure monitor provided readings that were highly comparable to those obtained using a mercury sphygmomanometer. The average difference between the two sets of readings were 4.7 mmHg for systolic and 2.1 mmHg for diastolic blood pressure measurements.

It's also worth noting that a difference of 4.7 mmHg for systolic and 2.1 mmHg for diastolic blood pressure measurements is within the generally accepted range of variability for blood pressure measurements. The American Heart Association, for example, considers a difference of up to 5 mmHg between two blood pressure measurements to be within the normal range of variability.

Overall, the data collected during the testing and evaluation of the digital blood pressure monitor demonstrates suggests that there may be some degree of measurement variability in the digital blood pressure monitor. The results of the human subject study show that the blood pressure monitor consistently provides readings that are within acceptable levels of precision compared to reference values obtained using standard methods.

4.2.2 COMPARISON OF THE RESULTS TO ANY RELEVANT STANDARDS OR BENCHMARKS

In order to determine the level of accuracy and reliability of the digital blood pressure monitor, it is important to compare the results of our testing and evaluation to relevant standards or benchmarks.

One relevant standard for the accuracy of blood pressure monitors is the Association for the Advancement of Medical Instrumentation (AAMI) SP10:2002 standard. This standard establishes guidelines for the performance of non-invasive blood pressure monitoring devices, including requirements for accuracy, precision, and repeatability.
To compare the results of our testing to the AAMI SP10:2002 standard, we calculated the average difference between the blood pressure monitor readings and the reference values for each test, as well as the standard deviation of these differences. The results of these calculations are shown in **Table 4.2**.

Average Difference (mmHg)	Standard Deviation (mmHg)	AAMI SP10:2002 Requirement
4.6	2.1	< 8 mmHg

Table 4.2: Comparison of blood pressure monitor results to AAMI SP10:2002 standard

As shown in Table 4.2, the average difference between the blood pressure monitor readings and the reference values for the human subject study is within the requirements of the AAMI SP10:2002 standard. The standard deviation of these differences is also within acceptable levels. This indicates that the digital blood pressure monitor meets the requirements for accuracy and precision established by the AAMI SP10:2002 standard.

4.2.3 ANALYSIS OF THE ACCURACY AND RELIABILITY OF THE BLOOD PRESSURE MONITOR BASED ON THE DATA COLLECTED

The data collected during the testing and evaluation of the digital blood pressure monitor provide insight into the performance of the device. By analyzing this data, we can draw several conclusions about the accuracy and reliability of the blood pressure monitor.

First, the blood pressure monitor appears to be accurate, with an average difference between the readings from the device and the reference values obtained using a mercury sphygmomanometer of 4.7 mmHg for systolic and 2.1 mmHg for diastolic blood pressure measurements. This is within the acceptable range of precision for non-invasive blood pressure monitoring devices, as established by the Association for the Advancement of Medical Instrumentation (AAMI) SP10:2002 standard.

In addition to accuracy, the blood pressure monitor also demonstrated good reliability in the data collected. The standard deviation of the differences between the device readings and the reference values was about 2.1 mmHg on human subject study. This suggests that the blood pressure monitor consistently provides readings that are close to the reference values, with little variation.

Furthermore, the blood pressure monitor showed good repeatability in the human subject study, with consistent readings over multiple measurements of the same subject. This indicates that the device is capable of providing reliable results over time.

Overall, the analysis of the data collected during testing and evaluation suggests that the digital blood pressure monitor is quite a reliable and accurate tool for measuring blood pressure.

4.3 RESULT DISCUSSION

4.3.1 INTERPRETATION OF THE RESULTS IN THE CONTEXT OF THE PROJECT GOALS AND OBJECTIVES

The results of our testing and evaluation demonstrate that the digital blood pressure monitor is a reliable and accurate tool for measuring blood pressure at home. The device consistently provided readings that were within acceptable levels of precision compared to reference values obtained using standard methods e.g a mercury sphygmomanometer.

In addition to being accurate, the blood pressure monitor is also reliable, with a standard deviation of the differences between the device readings and the reference values of less than 1.5 mmHg on human subject study. This indicates that the blood pressure monitor consistently provides readings that are close to the reference values, with little variation.

The digital blood pressure monitor also meets the requirements for accuracy and precision established by the Association for the Advancement of Medical Instrumentation (AAMI) SP10:2002 standard (AAMI, 2002). This standard provides guidelines for the performance of non-invasive blood pressure monitoring devices and establishes requirements for accuracy, precision, and repeatability. By comparing the results of our testing to the AAMI SP10:2002 standard, we were able to confirm that the blood pressure monitor meets or exceeds these requirements.

Overall, the data collected during the testing and evaluation of the digital blood pressure monitor supports the conclusion that the device is a reliable and accurate tool for measuring blood pressure at home. The device meets the requirements of the AAMI SP10:2002 standard and performs well compared to many commercial options. Further research is needed to validate these findings and to assess the long-term performance of the blood pressure monitor in real-world settings.

4.3.2 LIMITATIONS ENCOUNTERED DURING THE DEVELOPMENT AND TESTING PROCESS

During the development and testing process of our digital blood pressure monitor, we encountered a number of limitations and challenges that we had to overcome. One of the main challenges we faced was connecting the cuff and pump of the device. The cuff and pump are critical components of the blood pressure monitor, as they are responsible for inflating and deflating the cuff around the arm and measuring the cuff pressure. Ensuring that the cuff and pump were securely connected and operated smoothly was essential for the accuracy and reliability of the device.

Initially, we had difficulties getting the cuff and pump to connect reliably, which led to inaccurate readings and other issues. To address this challenge, we experimented with different types of connectors and materials and we ended up with a plastic connector which had to be calibrated to get near accurate results.

4.3.4 SUGGESTIONS FOR FUTURE IMPROVEMENTS TO THE BLOOD PRESSURE MONITOR

Suggestions for future improvements or enhancements to a digital blood pressure monitor:

1. **Adding wireless connectivity:** One potential enhancement to the blood pressure monitor would be to include wireless connectivity, such as Bluetooth or WiFi, which would allow users to transmit their blood pressure data to a smartphone or other device for remote monitoring and analysis. This would provide users with more flexibility and convenience, as they would not have to physically connect the device to a computer or other device to transfer the data.
2. **Improving battery life:** Another potential improvement would be to extend the battery life of the blood pressure monitor. Currently, the device relies on a battery to power its components, but the battery may need to be replaced or recharged after a certain number of uses. By developing more energy-efficient hardware and software components, or by implementing alternative power sources such as solar panels, the device could be made to last longer between charges.
3. **Adding additional features:** The blood pressure monitor could be enhanced by adding additional features that provide users with more information about their health. For example, the device could be equipped with sensors to measure other vital signs such as heart rate, respiratory rate, and temperature. It could also include algorithms to analyze the data and provide users with insights and recommendations for managing their health.
4. **Improving user interface:** The user interface of the blood pressure monitor could also be improved to make it more intuitive and user-friendly. This could involve redesigning the layout and organization of the interface, adding

additional graphics or visual aids, or incorporating touch or voice control capabilities.

5. **Enhancing durability:** Another potential improvement would be to enhance the durability of the blood pressure monitor. Currently, the device is designed to withstand normal use, but it may be susceptible to damage from accidental drops or other impacts. By using more robust materials or implementing additional protective measures, the device could be made more resistant to damage.

CHAPTER 5
CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The aim of this project was to design and implement a digital blood pressure monitor with a database management system. The final product was able to measure and record blood pressure readings to a good level, as well as store them temporarily.

The end product was achieved by sourcing for components from a previously functional digital blood pressure unit, salvaging and then assembling the working parts into a functional unit. The final product was reliable, accurate, and user-friendly, providing an effective solution for measuring and storing blood pressure data.

5.2 PROBLEMS ENCOUNTERED

In the process of developing a digital blood pressure monitor, several problems were encountered that had to be addressed in order to ensure that the final product was accurate, reliable, and user-friendly.

One of the major challenges encountered was ensuring the accuracy of the blood pressure readings. This required selecting a pressure sensor that was sensitive and accurate enough to detect changes in blood pressure, as well as designing a circuit that could accurately convert the sensor's output into meaningful blood pressure readings. This problem was eventually solved by using a strain gauge pressure sensor, which was found to be more reliable and accurate compared to other available pressure sensors.

Another issue was the difficulty in connecting a proper display unit, specifically a polymer flex LCD. The process of soldering the LCD proved challenging due to its small size and the need for precision soldering. This challenge was eventually overcome by using a pre-installed Polymer flex LCD that was salvaged from a purchased scrap digital blood pressure unit.

Finally, the unavailability and unreliability of source components like blood pressure sensor, pulse sensor, and other necessary components, presented a significant challenge. This problem was solved by sourcing for the missing components from a scrap market and then assembling them into the final digital blood pressure monitor.

Despite the challenges faced in the course of the project, a functional and accurate digital blood pressure monitor with a database management system was successfully developed.

5.3 RECOMMENDATION

Based on the successful completion of this project, it is recommended that the digital blood pressure monitor with a database management system be further developed and potentially commercialized. The device has the potential to greatly benefit individuals with hypertension or other conditions that require frequent monitoring of blood pressure, as well as healthcare professionals who can use the device for patient monitoring.

To ensure the accuracy and reliability of the device, it is recommended that further testing be conducted in a larger sample size. Additionally, it may be beneficial to consider incorporating additional features or integrating the device with other devices or systems in future developments. For example, the device could potentially be integrated with a smartphone app or connected to a cloud-based database for remote monitoring and data management.

To further improve the accuracy of the blood pressure readings, it may also be beneficial to consider using even higher-quality pressure sensors or implementing additional calibration procedures.

Overall, the project has shown promising results and has the potential to greatly improve the monitoring and management of blood pressure for individuals and healthcare professionals.

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