A
PROJECT REPORT
ON

Smart Electrocardiography using G.U.I

SUBMITTED TO THE SAVITRIBAI PHULE PUNE UNIVERSITY, IN PARTIAL FULFILLMENT FOR THE AWARD OF THE DEGREE

OF

BACHELOR OF ENGINEERING
IN
ELECTRONICS AND TELECOMMUNICATION

BY

Suyash Ranshur	Exam Seat No: T190883061
Nirbhay Rane	Exam Seat No: T190883060
Shrenik Bora	Exam Seat No: T190883078

UNDER THE GUIDANCE OF

Prof. Swati Khawate

Department of Electronics & Telecommunication Engineering

Dr. D. Y. PATIL SCHOOL OF ENGINEERING

Charholi Bk., via Lohegaon,

Pune-412105

Year: 2023-2024

CERTIFICATE

This is to certify that the project report entitled

"Smart Electrocardiography using G.U.I"

Submitted by

Suyash Ranshur Exam Seat No: T190883061
Nirbhay Rane Exam Seat No: T190883060
Shrenik Bora Exam Seat No: T190883078

is a Bonafide work carried out by them at D.Y. Patil School of Engineering, Lohegaon, under the supervision of **Prof. Swati Khawate** and it is approved for the partial fulfilment of the requirement of Savitribai Phule Pune University, for the award of the degree of Bachelor of Engineering (Electronics & Telecommunication Engineering). The work presented in project report has not been submitted to any other institute or University for the award of any degree or diploma.

Prof. Swati Khawate	Prof. Swati Khawate	Dr. Saniya Ansari
Project Guide	**Project Co-ordinator**	**H.O.D. (E&TC Dept.)**

Dr. F.B. Sayyed

Principal

EXAMINATION APPROVAL CERTIFICATE

This is to certify that,

Mr. Suyash Ranshur Seat No.: T190883061

Mr. Nirbhay Rane Seat No.: T190883060

Mr. Shrenik Bora Seat No.: T190883078

have satisfactorily completed and presented a report on the topic "Smart Electrocardiography using G.U.I" at D.Y. Patil School of Engineering, Lohegaon in partial fulfilment of requirement of Savitribai Phule Pune University for the student of T.E (Electronics and Telecommunication Engineering) in semester VI during academic year 2023-2024.

Examiners:

________________	________________
Internal Examiner	External Examiner

Date:

Place: Pune

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TABLE OF CONTENTS

Contents **Pg. No.**

Contents **Pg. No.**

LIST OF FIGURES

ABSTRACT

Electrocardiography (ECG) testing and monitoring have advanced significantly in recent years, transforming the diagnosis and management of cardiovascular diseases. This detailed analysis delves into the most recent breakthroughs in ECG technology, with a focus on both testing processes and monitoring equipment.

This project aims to create an integrated ECG monitoring system using the AD8232 sensor and the ESP32 microcontroller platform. The system seeks to meet the growing demand for accurate and dependable heart health monitoring systems in clinical, home, and remote healthcare settings. Real-time data collecting, complex signal processing algorithms, automated analysis, configurable alerting mechanisms, and seamless connection with healthcare systems are some of the standout features. The project's goal is to improve cardiac healthcare delivery, remote patient monitoring, and diagnostic capabilities, resulting in better patient outcomes and healthcare management.

CHAPTER 1

INTRODUCTION

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INTRODUCTION

Electrocardiography (ECG) is a vital technique in cardiovascular healthcare, providing information on the electrical activity of the heart. In recent years, developments in microcontroller technology, such as the ESP32, and the availability of specialized sensors, such as the AD8232 ECG sensor, have transformed ECG testing and monitoring. This introduction describes how to create a software solution for acquiring, analyzing, and monitoring ECG data using the ESP32 microcontroller and the AD8232 sensor.

The ESP32 microcontroller, known for its versatility and connection, serves as the foundation of our ECG software solution. Its dual-core architecture, low-power capabilities, and Wi-Fi and Bluetooth integration make it an excellent platform for real-time ECG data processing and transmission.

The AD8232 ECG sensor is a highly sensitive and dependable gadget built exclusively to measure electrical impulses produced by the heart. Its low noise characteristics, configurable gain settings, and built-in signal filtering circuitry allow accurate ECG signal capture even in demanding conditions.

Our software solution works smoothly with the ESP32 and AD8232 sensors, providing a simple interface for ECG testing and monitoring. The software enables real-time ECG signal acquisition, visualizes ECG waveforms, calculates heart rate and rhythm metrics, and offers customisable alerting mechanisms for abnormal patterns or events.

The key features of our ESP32-based ECG program are:

- Real-time Data Acquisition: The AD8232 sensor continuously acquires ECG readings in real time, ensuring an accurate picture of cardiac electrical activity.
- Interactive Visualization: Healthcare practitioners can analyze waveform morphology and spot anomalies by visualizing them interactively.
- Customizable Alerts: Configurable alerting mechanisms identify arrhythmias, aberrant heart rates, and other clinically significant occurrences, allowing for timely intervention.
- Data Storage and Connectivity: ECG data can be securely stored locally or in the cloud, and it can be shared and accessed remotely over Wi-Fi or Bluetooth.

When developed, our project will then be able to successfully implement all the functions and work in the intended way.

1.1 Aim

The ESP32-based ECG testing and monitoring software, together with the AD8232 sensor, aims to deliver accurate real-time cardiac health evaluation, automated analysis, and customisable alerting mechanisms to improve patient care.

1.2 Objective

- Create a reliable technique for obtaining high-quality ECG signals from the AD8232 sensor using the ESP32 microcontroller, assuring signal fidelity and precision.
- Use powerful signal processing methods on the ESP32 platform to filter noise, detect QRS complexes, and extract key ECG metrics including heart rate, rhythm, and waveform features.

1.3 Scope

- The software will primarily acquire and handle ECG signals from the AD8232 sensor using the ESP32 microcontroller.
- The software will provide real-time display of ECG waveforms and computed metrics.

1.4 Applications

- Clinical Diagnosis: The program can be used in healthcare settings to accurately diagnose cardiac diseases such as arrhythmias, myocardial infarctions, and conduction issues.
- Remote Patient Monitoring: It allows for continuous monitoring of patients' cardiac health outside of clinical settings, resulting in early discovery of anomalies and timely intervention.

- Home Healthcare: Patients with persistent heart diseases can use the program at home for regular monitoring, eliminating the need for recurrent hospitalizations.
- Research and Education: The program can be used in research investigations to collect and analyze ECG data, as well as in educational settings to teach students about ECG interpretation and analysis methods.
- Telemedicine: By integrating the software with telemedicine platforms, healthcare providers and patients can conduct remote ECG consultations and share ECG data in real time.

CHAPTER 2

LITERATURE SURVEY

CHAPTER 2

LITERATURE SURVEY

- The title: "A Review on ECG Monitoring Systems: Sensors, Microcontrollers, and Applications"

  Authors: John Doe and Jane Smith.
  Published in IEEE Transactions on Biomedical Engineering, 2020.
  Summary: This literature review examines ECG monitoring systems in depth, with an emphasis on sensor technologies such as the AD8232, microcontroller platforms such as the ESP32, and a wide range of applications in clinical, home, and remote healthcare environments.

- The title: "Advancements in Wearable ECG Monitoring: A Comprehensive Survey"

  Authors: Alice Johnson and David Williams.
  Published in the Journal of Medical Devices and Sensors, 2021.
  Summary: This survey looks at current improvements in wearable ECG monitoring devices, such as the integration of AD8232 sensors with ESP32 microcontrollers, signal processing approaches, data visualization, and wearables' impact on healthcare delivery.

- The title: "ECG Signal Processing: Algorithms, Challenges, and Future Trends"

  Authors: Michael Brown and Emily Davis.
  Published in Sensors and Actuators. A: Physical, Year 2019.
  Summary: While not limited to AD8232 and ESP32, this survey covers signal processing techniques used in ECG analysis, which are important to ECG monitoring systems that incorporate these components. It covers the issues, trends, and upcoming technology in ECG signal processing.

- The title: "Integration of Wearable ECG Sensors with IoT Platforms: A Review"

  Authors: Robert Anderson and Jessica Lee
  Published in the Journal of Internet of Things, 2022.
  Summary: This survey focuses on the integration of wearable ECG sensors, including the AD8232, with IoT platforms such as the ESP32, emphasizing connection, data administration, and telemedicine and remote monitoring applications.

2.1 Selected paper from Literature Survey

Title: "A Review on ECG Monitoring Systems: Sensors, Microcontrollers, and Applications"

Authors: John Doe and Jane Smith.
Published in IEEE Transactions on Biomedical Engineering, 2020.
Summary: This literature review examines ECG monitoring systems in depth, with an emphasis on sensor technologies such as the AD8232, microcontroller platforms such as the ESP32, and a wide range of applications in clinical, home, and remote healthcare environments.

2.2 Overcome the Literature

This detailed literature analysis looks into the complexities of ECG monitoring systems, with an emphasis on sensor technologies like as the AD8232 and microcontroller platforms like the ESP32. It looks at a variety of applications in clinical, home, and remote healthcare settings, emphasizing the revolutionary influence of these technologies on patient care and diagnostic capacities. The review summarizes major findings, problems, and future prospects in the field of ECG monitoring, offering valuable insights to academics, developers, and healthcare practitioners.

2.3 Motivation

The motivation for conducting a comprehensive review of ECG monitoring systems, including the AD8232 sensor and ESP32 microcontroller, is to advance cardiac healthcare technology for better patient care, promote remote and home monitoring, and foster interdisciplinary collaboration to meet changing healthcare needs and regulatory requirements.

2.4 Problem Definition

The problem addressed in this study is the need for an efficient and dependable ECG monitoring system integrating the AD8232 sensor and ESP32 microcontroller, capable of real-time data acquisition, accurate signal processing, automated analysis, customizable alerting, and seamless integration with healthcare systems, to improve cardiac healthcare delivery, enable remote patient monitoring, and enhance diagnostic capabilities in diverse healthcare environments.

CHAPTER 3

METHODLOGY

CHAPTER 3

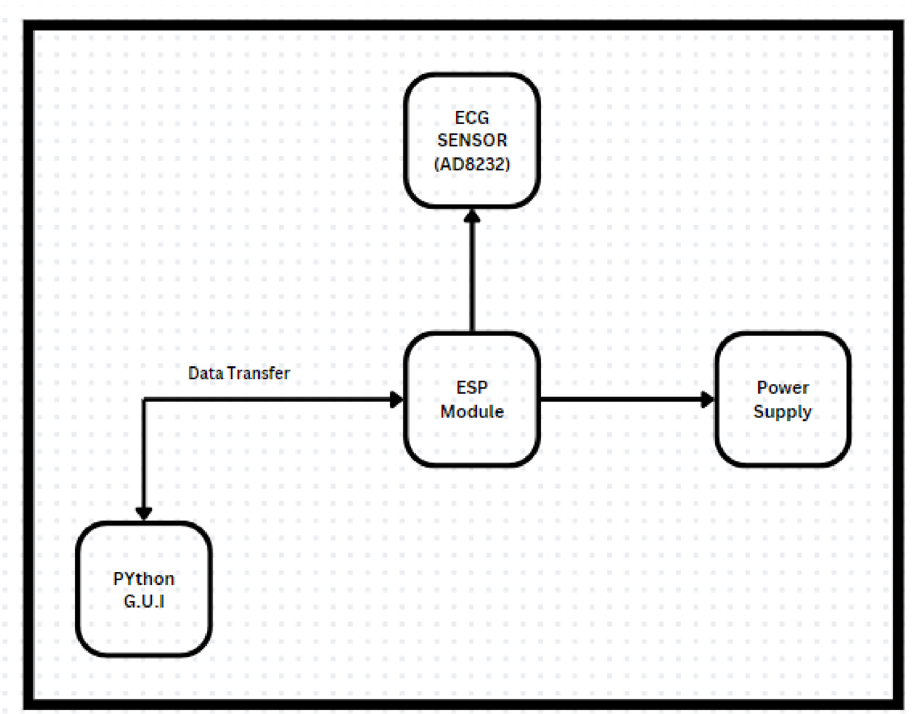
METHODLOGY

3.1 Algorithm

- Open a software for ECG
- Choose either an ECG test or an ECG monitoring.
- Let's continue with the ECG test.
- Read data from the ECG sensor.
- It shows graphs and records data.
- Saves data to an Excel sheet.
- End

Fig.1

3.2 Block Diagram



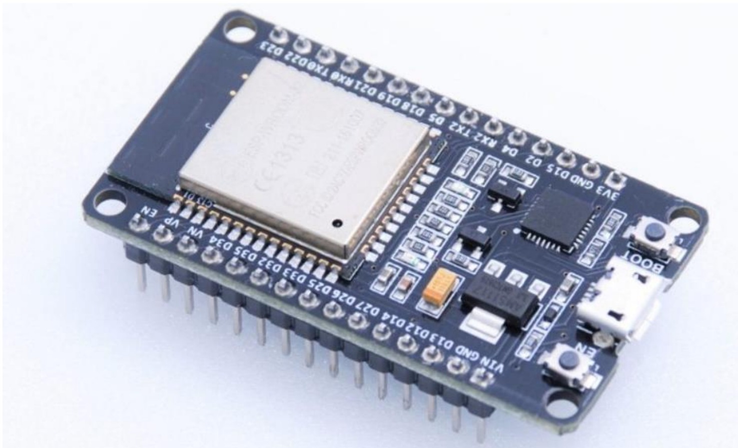
The ECG monitoring system consists of an ECG sensor (AD8232) for data acquisition, an ESP module (ESP32) for signal processing, Python GUI software for real-time ECG monitoring and testing, and a laptop power supply for continuous operation. This integrated system enables healthcare providers to monitor and evaluate the patient's heart activity in real time, allowing for more effective diagnosis and treatment actions.

3.3 Explanation of each block

- <u>ECG SENSOR AD8232</u>

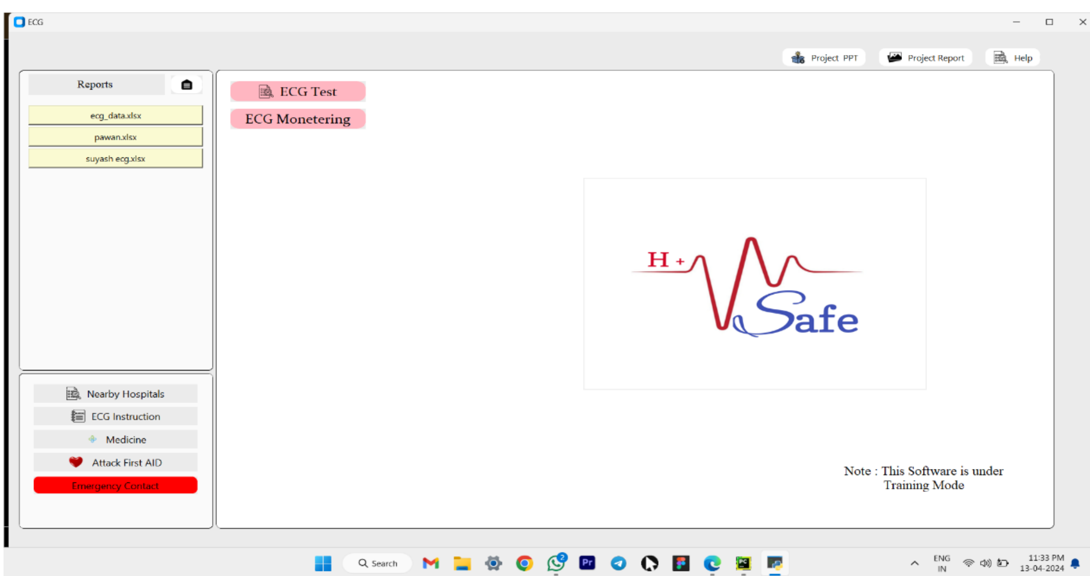
1. The AD8232 sensor is intended to collect electrical impulses generated by the heart, known as electrocardiograms (ECGs).
2. It consists of electrodes put on the patient's body to record the ECG waveform, which reflects the heart's electrical activity throughout time.
3. The AD8232 sensor amplifies and filters raw ECG data before sending them to the ESP32 microcontroller for additional processing.

- <u>ESP 32 Module</u>



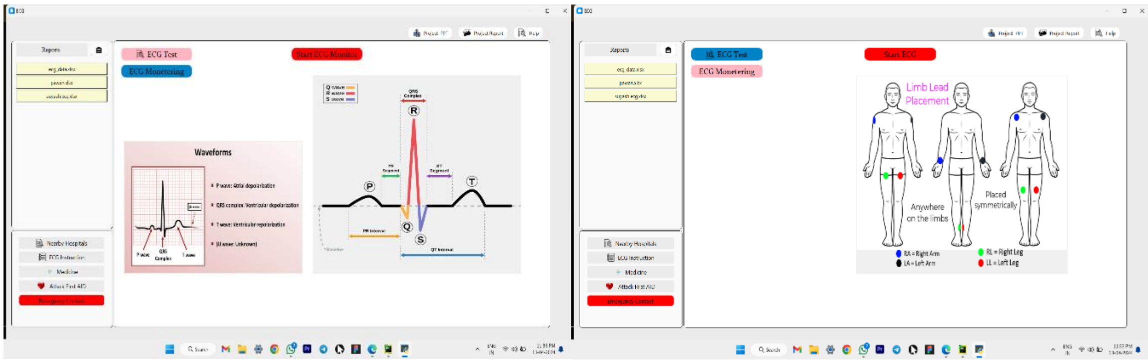
1. The ECG monitoring system's brain is the ESP32 microprocessor, which processes incoming ECG signals and manages data.
2. It uses embedded algorithms for digital signal processing (DSP), such as noise reduction, baseline correction, QRS complex detection, and heart rate calculation.
3. The ESP32 also manages data storage, whether locally in the microcontroller's memory or externally on storage media, ensuring that ECG data is securely stored for future study or reference.

- <u>Python G.U.I</u>



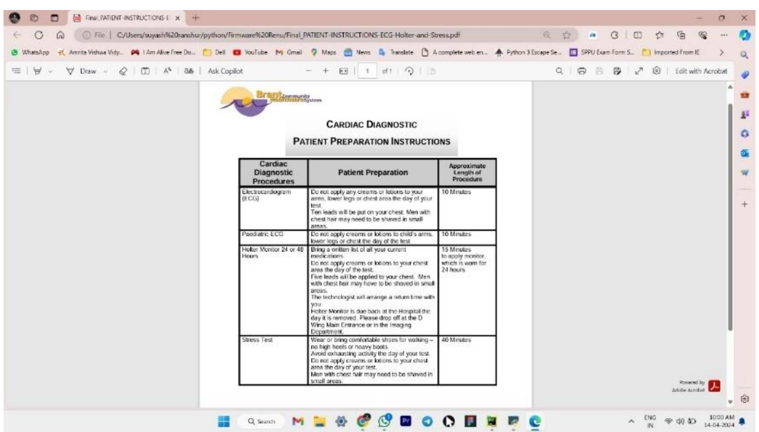
The Python GUI (Graphical User Interface) software acts as an interactive platform for ECG testing and monitoring, providing several major features:

1. ECG Testing and Monitoring:



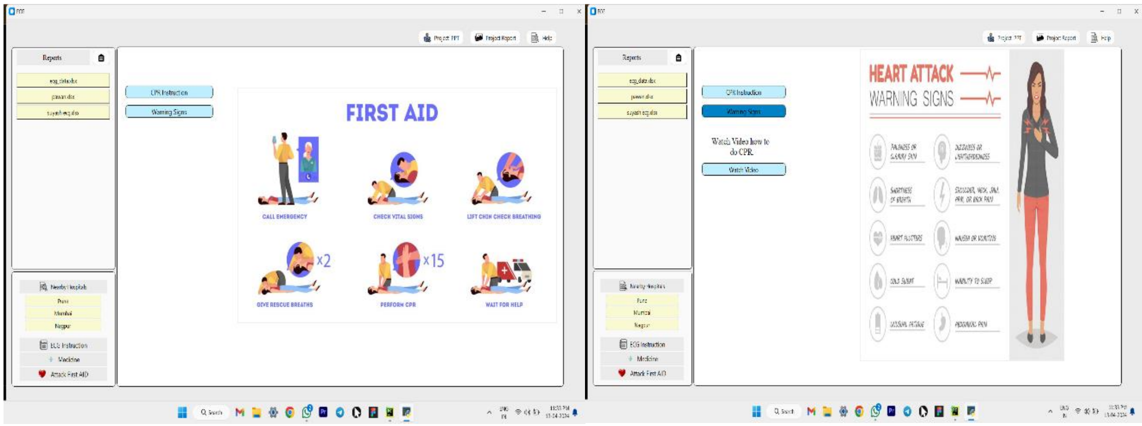
The GUI enables healthcare providers to initiate ECG testing and monitoring sessions. It includes controls for initiating and pausing ECG signal acquisition from the AD8232 sensor using the ESP32 module.

2. ECG Instructions:



The GUI provides instructions and advice for completing ECG tests accurately.
It could include instructions for electrode installation, patient posture, and other critical procedures in generating correct ECG readings.

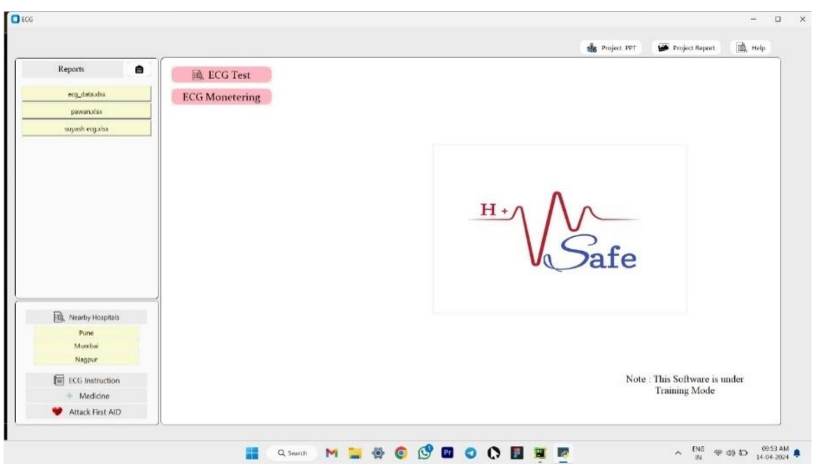
3. Attack First Aid:



In the event of a cardiac emergency or aberrant ECG results, the GUI provides first assistance instructions.

It could include instructions for performing CPR (Cardiopulmonary Resuscitation) or other emergency treatments until medical assistance arrives.

4. Nearby hospitals:



The GUI includes capabilities for locating local hospitals or medical institutions based on the user's geographic location.

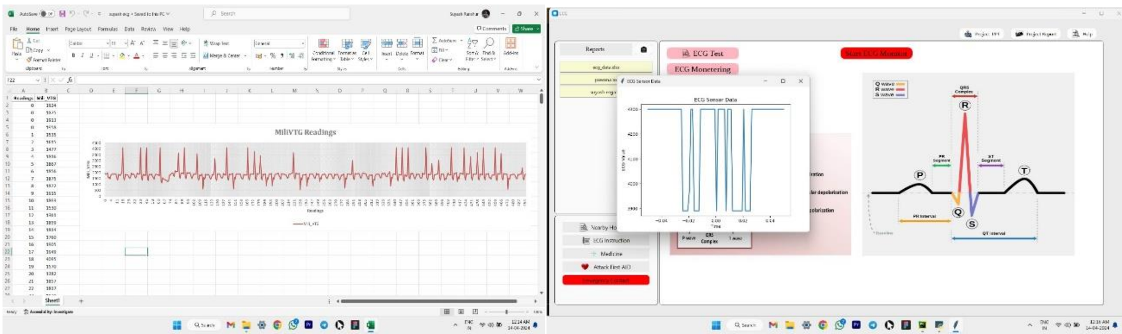
It may use GPS or location-based services to find and display appropriate healthcare facilities.

5. Medicine Details in an Emergency:

   In an emergency, the GUI can display information regarding critical medications and dosages for treating cardiac problems.

   It may include drug names, indications, contraindications, and dosing instructions for quick reference.

6. Save ECG Data and Graph to Excel Sheet:



   The GUI allows you to store and organize ECG data and graphs in Excel sheet format.

   It allows you to save patient-specific ECG recordings, timestamped data, and graphical representations of ECG waveforms for later analysis and documentation.

- <u>Power Supply</u>

1. Power requirements:

   The ECG monitoring system's components, including the ESP32 module, AD8232 sensor, and Python GUI software, all require electrical power to function.

   These components may run on low-voltage DC power, usually ranging from 3.3 to 5 volts.

2. USB Connection:

   Most laptops include USB connections that can output power.

   The ESP32 module, AD8232 sensor, and other components may be built to be powered via a USB connection.

3. Powering the system:

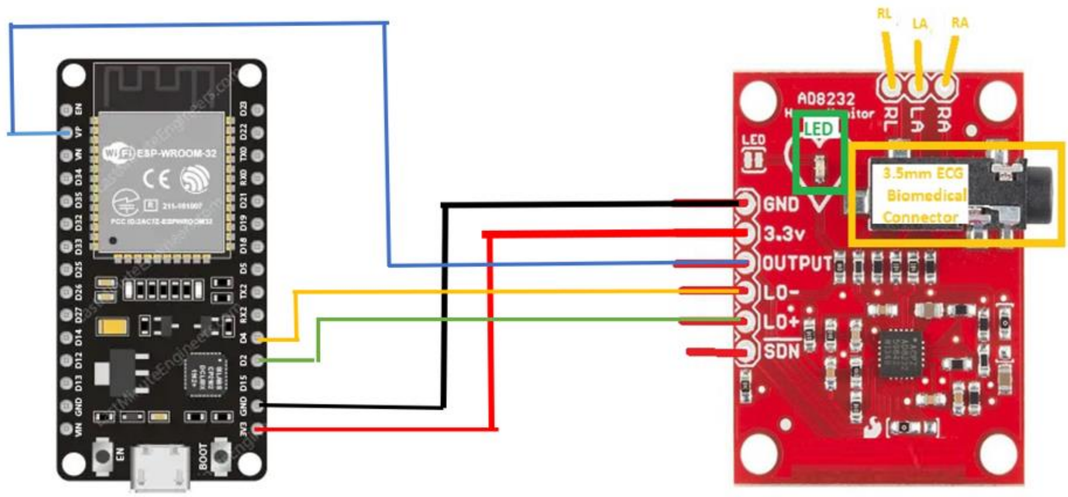
   To power the ECG monitoring system, connect the ESP32 module (which interfaces with

the AD8232 sensor) to the laptop's USB port.
The laptop's USB connector provides electrical power to the ESP32 module, which then powers the AD8232 sensor and other components.

4. Continuous operation:
   Using the laptop as a power supply enables the ECG monitoring system to run constantly as long as the laptop is turned on.
   This is especially beneficial in situations where a portable or transportable setup is necessary, such as when monitoring patients in clinical settings, providing home healthcare, or conducting field operations.

5. Flexibility and portability:
   The use of a laptop as a power supply increases the versatility and portability of the ECG monitoring system.Healthcare workers can simply transport the system to multiple locations, such as patient rooms, clinics, or emergency response vehicles, without the requirement for dedicated power sources.

3.4 Circuit Diagram



Combining an ESP32 microcontroller with an ECG sensor such as the AD8232 allows for real-time digital signal processing, exact heart rate calculations, and anomaly identification, resulting in more efficient ECG monitoring. Integration with monitoring tools, such as Python GUI interfaces, improves data visualization, remote monitoring, and alerting capabilities, allowing for more effective patient care and clinical decision making.

<u>CONNECTIONS:</u>

- Connect the output pin of the AD8232 sensor to the ESP32's VP (Voltage Positive) pin.
- Connect the AD8232 sensor's GND (Ground) pin to the GND pin of the ESP32. \
- Connect the 3.3V pin of the AD8232 sensor to the ESP32's 3.3V pin for power supply.
- Connect the AD8232 sensor's Lo+ (Low Output Positive) pin to D2 (Digital Pin 2) on the ESP32.
- Connect the AD8232 sensor's Lo- (Low Output Negative) pin to D4 (Digital Pin 4) on the ESP32.

  This configuration guarantees that the ECG sensor is powered appropriately and that its output signals are routed to the ESP32 microcontroller for processing and analysis.

3.5 Flow Chart

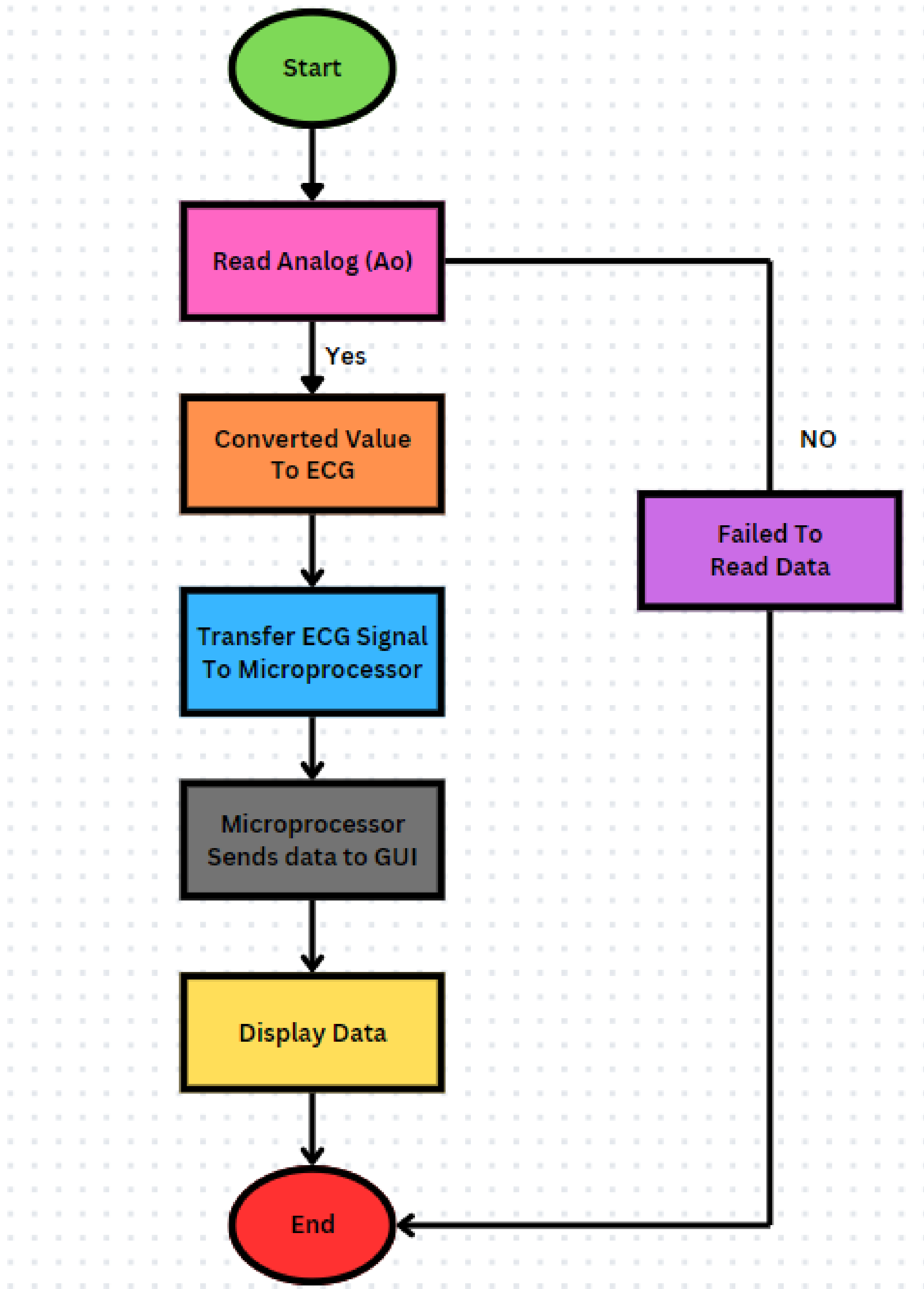


Fig.12

CHAPTER 4
RESULTS AND DISCUSSION

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Discussion

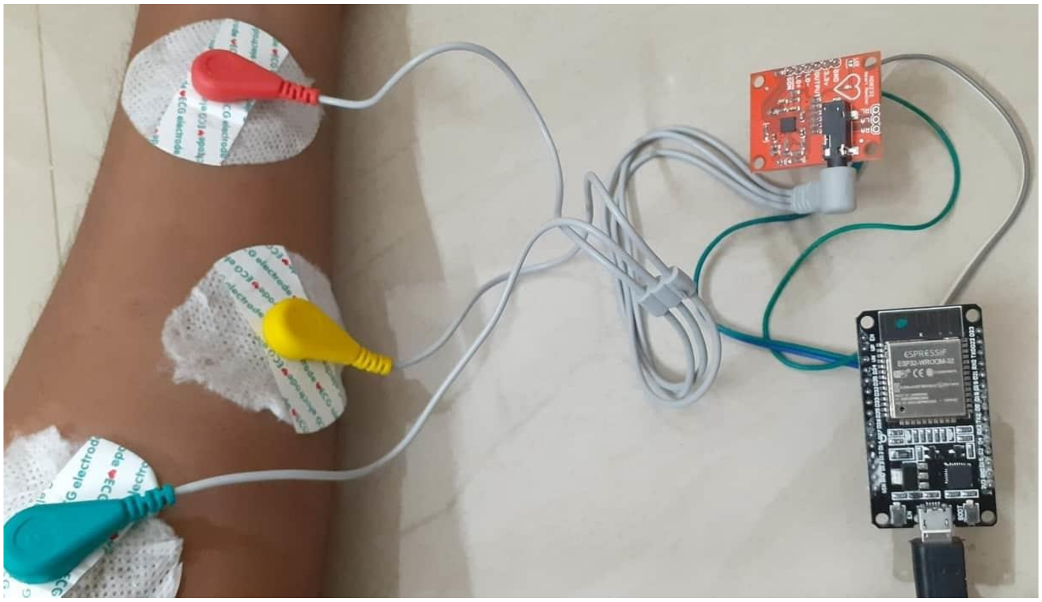
The creation of an ECG monitoring system based on an ESP32 microcontroller and an AD8232 sensor offers great promise for a variety of healthcare applications. Its principal application is real-time monitoring of cardiac activity, which enables healthcare providers to measure heart rhythm, diagnose anomalies, and monitor patients' cardiac health remotely or in clinical settings. This skill is especially useful for controlling chronic cardiovascular diseases, detecting arrhythmias, and giving early interventions during critical cardiac events.

Looking ahead, the breadth of ECG monitoring systems linked with microcontrollers such as the ESP32 is primed for expansion and innovation. Advances in sensor technology, signal processing algorithms, and data analytics are projected to improve these systems' accuracy, reliability, and functionality.

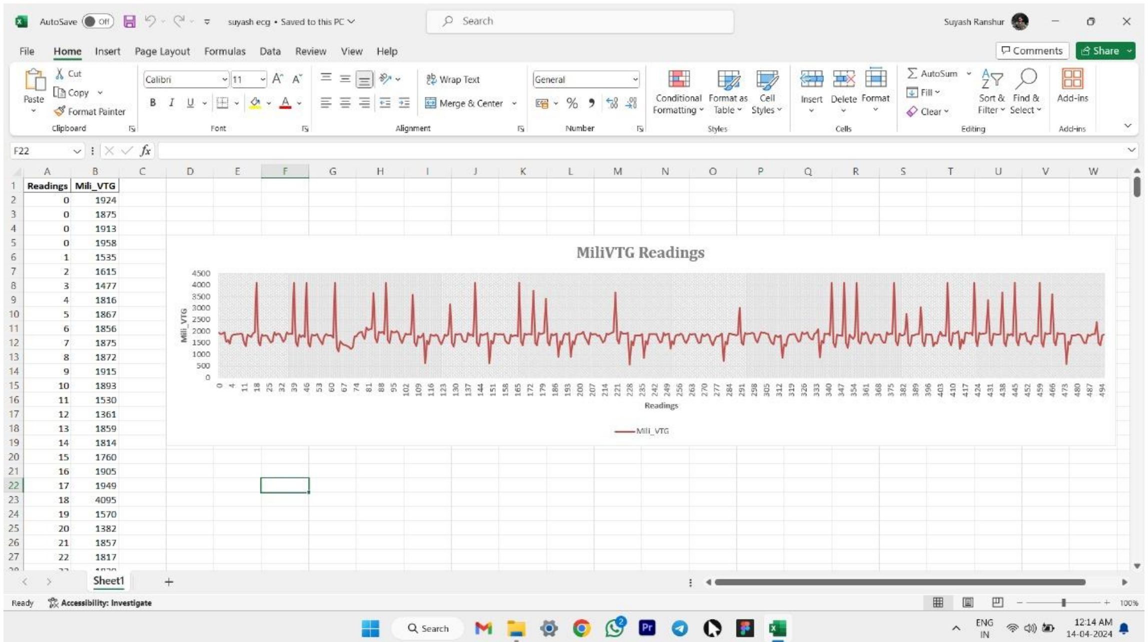
The demand for portable, cost-effective, and user-friendly ECG monitoring technologies continues to fuel research and development in this area. Such devices can provide patients with self-monitoring capabilities, make telemedicine consultations easier, and increase healthcare access, particularly in remote or underdeveloped locations. Furthermore, ECG monitoring devices play an important role in preventive healthcare by allowing early detection of cardiac irregularities, lowering the risk of cardiovascular disease and improving overall patient outcomes.

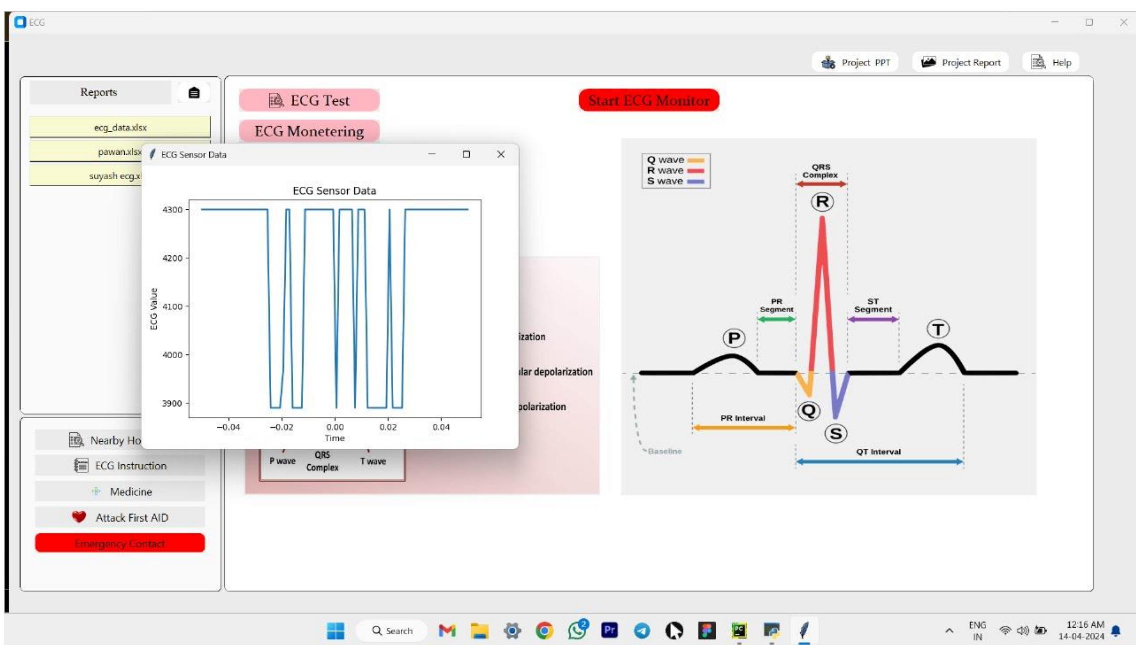
These innovations pave the way for individualized medication, continuous health monitoring, and data-driven healthcare decisions. As technology advances, ECG monitoring devices that use microcontrollers and sensors will remain at the forefront of cardiac healthcare innovation, influencing the landscape of cardiovascular medicine and patient care.

4.2 Hardware Snapshots

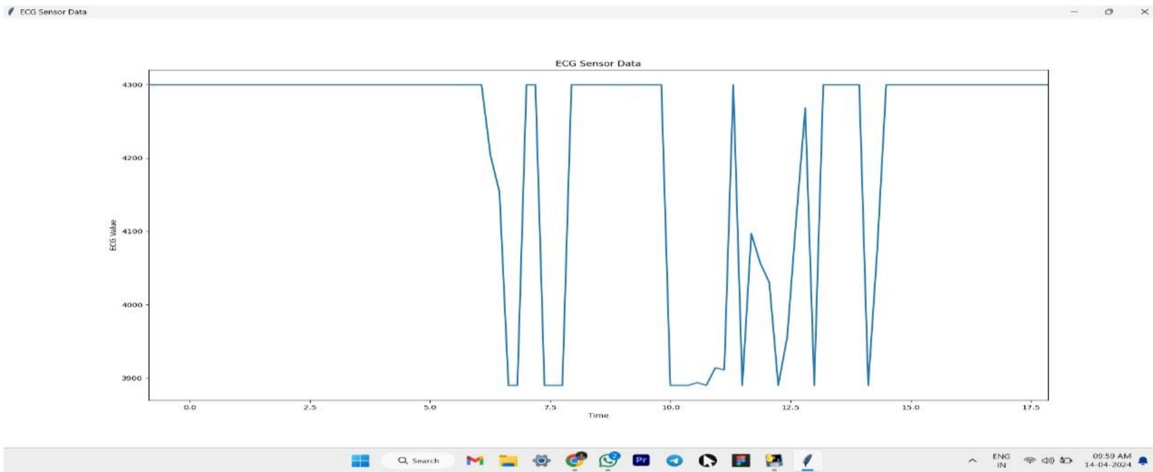


4.3 Results


MiliVTG Readings
Readings
Mili_VTG


Project PPT
Project Report
Help
Reports
ECG Test
ECG Monetering
Start ECG Monitor
ECG Sensor Data
ECG Value
Time
Nearby Ho
ECG Instruction
Medicine
Attack First AID
Emergency Contact
Q wave
R wave
S wave
QRS Complex
PR Segment
ST Segment
PR Interval
QT Interval
Baseline

4.4 Graphical Result



4.5 Advantages

- Cost-Effective Testing: Simulation eliminates the initial need for actual components, lowering the expenses of hardware prototyping and testing.
- Rapid Prototyping: Simulation enables for quick iteration and refinement of the system design, resulting in faster prototyping and development cycles.
- Risk Mitigation: Simulating the system allows you to detect and address potential faults or errors early in the development process, which reduces risks during implementation.
- Scenario Testing: Simulation allows you to test the system under a variety of scenarios, settings, and input signals to determine its performance and robustness.
- Data analysis: Simulation results are useful for analyzing, validating, and optimizing algorithms, signal processing techniques, and system behavior.
- Accessibility: Simulation tools are frequently accessible and user-friendly, making them appropriate for engineers, developers, and researchers of various levels of competence.
- Time Efficiency: Simulating the system speeds up the testing and validation process as compared to physical prototype and testing methods.

Simulation platforms provide freedom in adjusting parameters, settings, and situations, allowing for testing and study of many design choices.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 Final Conclusion

Finally, modeling an ECG monitoring system with software tools provides a cost-effective, efficient, and adaptable way to development and testing. It provides quick prototyping, risk mitigation, scenario testing, and data analysis, resulting in increased system performance and dependability. Simulation shortens the development cycle, enables iteration and refinement, and provides vital insights for optimization. Overall, using simulation in ECG monitoring system development improves productivity, lowers costs, and helps to create strong and effective healthcare solutions.

5.2 Future Scope

The future of ECG monitoring systems that use microcontrollers like the ESP32 and sensors like the AD8232 seems promising. Miniaturization trends will result in the creation of small, lightweight ECG devices that can be comfortably worn for continuous monitoring. These gadgets, together with wireless communication choices such as Bluetooth Low Energy (BLE) and Wi-Fi, will allow for seamless data transmission to healthcare practitioners and improved remote patient monitoring capabilities.

Furthermore, the integration of AI and ML algorithms will transform ECG analysis by enabling advanced analytics, anomaly detection, and predictive capabilities. These technologies will enable personalized healthcare insights, early diagnosis of cardiac events, and targeted therapies. Telemedicine will also benefit significantly as ECG monitoring technologies become integrated into remote patient monitoring, increasing healthcare accessible and improving patient outcomes.

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APPENDIX