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ECG Monitoring With Mobile Connectivity

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Abstract - *Heart-related diseases are a cause of death worldwide. This makes checking the heart very important. We present a system that checks the hearts activity in time. It uses an AD8232 ECG sensor and an ESP32 microcontroller. The system uses electrodes to measure the hearts electrical activity. The weak signals are made stronger. Cleaned up. They are then sent to a device or cloud platform using Bluetooth or Wi-Fi. A mobile app or web page shows the ECG waveform in time. It also calculates things like heart rate. The system is designed to be cheap, portable and easy to use. This makes it good for checking hearts especially in areas, with limited resources. We tested the system. It works well. It can get signals show them in real-time and communicate wirelessly. This shows that IoT-based health monitoring systems can help people get healthcare.*

Key Words: ESP32, AD8232 Sensor, ECG Electrode, OLED, Thing Speak

1. INTRODUCTION

Electrocardiography or ECG is an used test that checks the hearts electrical activity. It helps diagnose heart conditions like arrhythmia, tachycardia and ischemic heart disease. Hospital ECG machines are very accurate. They are often big, costly and not good for long-term monitoring. Patients in areas or developing countries may have trouble getting to healthcare facilities. This can delay diagnosis and treatment. Wearable devices, the Internet of Things and mobile computing are advancing rapidly. These technologies can help with heart monitoring. ECG is a tool for checking heart health. It is used to diagnose heart conditions. The hearts electrical activity is checked with ECG. This helps doctors understand heart prob lems. ECG machines in hospitals are very reliable. They are not portable. Patients, in areas face challenges. They have to travel to get medical help. This delay can be life threatening. With new technologies things are changing. The Internet of Things and mobile computing are improving. These advancements will help with heart monitoring. ECG will remain a tool. It will help doctors diagnose and treat heart conditions. Time remote health monitoring is very important. It helps people a lot. Portable ECG devices with communication make it possible to continuously monitor heart activity outside of hospitals. These systems make patients feel more comfortable. They do not need to visit hospitals Doctors can also monitor patients from away. This project is about creating a real-time ECG monitoring system. It will have an interface. The system uses the AD8232 ECG sensor module. It also uses an ESP32 microcontroller. The AD8232 makes weak ECG signals stronger. It filters them too. The ESP32 converts analog signals to digital. It also sends data wirelessly. The ECG data is sent to an app. It can also go to a web-based dashboard. The waveform is shown in time. The heart rate is also calculated. The system wants to be small. It wants to be cheap. It wants to be reliable. It can monitor ECG continuously. It is very useful for telemedicine. It helps patients in areas. It helps patients in areas, with medical help. The system combines sensing. It combines processing. It combines communication. It makes healthcare monitoring better. It makes healthcare monitoring more accessible.

2. LITERATURE SURVEY

I looked into reviews and papers from 2018 to 2025 on wearable ECG devices, specifically those that use the AD8232 as an analog front end. These papers covered things like microcontroller-based IoT ECG implementations using the ESP32, integration with smartphones and the cloud and clinical validation of ECG for detecting atrial fibrillation. I also came across emerging AI and ECG analysis. The search terms I used included" ECG review" "AD8232 ESP32 IoT ECG" and "remote ECG monitoring telemedicine". The AD8232 is a choice for portable ECG systems because it can extract small biopotentials and reduce motion and noise. Many papers and the datasheet describe how suitable it is for lead portable ECG designs. The ESP32 is often used in IoT ECG projects to digitize the AD8232 output and stream data to apps or cloud dashboards. Commercial lead mobile ECGs like the Alive Cor Kardia Mobile and Apple Watch have been clinically validated for detecting atrial fibrillation. These devices show sensitivity and specificity for AF in many settings. Kamga et al., 2022 wrote about the use of ECG devices in clinical settings. This review is useful for understanding adoption and limits. The AD8232 datasheet from Analog Devices is an hardware reference for AFE design. Neriet al., 2023 reviewed devices and AI pipelines for ECG analysis. This is good for ideas on integrating AI. The AD8232 helps with conditioning through amplification and filtering. This makes it easier to get data from wearable ECG devices. The ESP32 handles data acquisition, filtering and uploading to the web or cloud. Wearable ECG devices are useful for monitoring and detecting heart conditions.

3. METHODOLOGY

The proposed real-time ECG monitoring system works in four steps. First it gets the ECG signal. Then it makes the signal better. Turns it into digital form. After that the ECG monitoring system sends this data wirelessly. Finally the ECG monitoring system shows this information in time.

A. Signal Acquisition

We get ECG signals by putting electrodes, on the human body. These electrodes usually go on the chest or arms. The electrodes find the electrical signals that happen with each heartbeat. ECG signals are really weak so we need to make them stronger before we can work with them. This is because ECG signals are usually very small a few millivolts. So we have to amplify ECG signals before we can do anything with them.

An AD8232 ECG sensor module is used as the front end of the system. The AD8232 module is designed for measurements. It provides high-gain amplification. Has built in filter circuits. The AD8232 helps reduce motion artifacts and power-line interference using pass and low-pass filters. This helps produce a cleaner and more stable ECG waveform from the AD8232.

B. Signal Conditioning and Digitization

The ECG signal from the AD8232 module is connected to the ESP32 microcontroller. This microcontroller has something called an analog-to-digital converter. The ESP32 micro controller takes the ECG signal. Turns it into a digital signal. The ESP32 microcontroller does this by taking samples of the ECG signal at a rate. The ECG signal is then made stable. This is done by using a filter to remove extra noise from the ECG signal. The ECG signal from the ESP32 microcontroller is now, in a form and is ready to be sent.

C. Wireless Data Transmission

The ESP32 microcontroller includes built-in Bluetooth and Wi-Fi modules, which are used to transmit ECG data wirelessly.
Two communication modes are supported:

Bluetooth Mode: When the device is in this mode it sends the ECG data to a smartphone that is close by. The ECG data is then picked up by an application, on the smartphone. This mobile application gets the ECG data. Shows the ECG waveform on the screen as it happens.

Wi-Fi Mode: In this mode the ECG data is sent to a server or an Internet of Things platform, like Thing Speak, Blink or Firebase. This allows doctors and nurses to view the ECG signals from anywhere. They can access it remotely. The ECG data is up loaded to these platforms. This helps healthcare professionals to monitor patients remotely. They can check the ECG signals from any location.

D. Real-Time Visualization and Heart Rate

Calculation when you use the application or the web interface you can see the ECG data as a continuous line on the screen. This line shows what is happening with your heart. The computer program looks at this line. Finds the peaks. It uses these peaks to figure out how times your heart beats in one minute. This is called the heart rate. It is measured in beats, per minute or BPM. The mobile application and the web interface do this with the ECG data. The system is able to make reports in PDF or CSV format. These heart reports can be. Sent to doctors, like Dr Smith for more review. If the system finds heart rhythms it will send alerts or notifications to the doctors. The system will send these alerts so doctors can look at the heart reports more.

E. Simulation and Testing

Before we actually built the hardware we tested the system using the Wokwi simulator. We set up a simulation with an ESP32 microcontroller, an ECG signal and an OLED display to show the waveform. The output of the AD8232 ECG sensor which's the analog ECG signal is connected to one of the analog input pins of the ESP32 like GPIO34. The ESP32 then looks at the ECG signal it gets and draws it on the OLED display in time. It uses the Adafruit GFX and SSD1306 libraries to do this. We also tested what would happen if we used Wi-Fi or Bluetooth to connect to the internet. We wanted to see if we could send data from a device to a cloud server. The AD8232 ECG. The ESP32 microcontroller work together to make this happen. The ESP32 microcontroller is really good, at analyzing the ECG signal from the AD8232 ECG sensor. We did some testing to see if our system works like it is supposed to. The test showed that we can make waveforms in time connect to things without using wires and keep sending data all the time. We also tested to see if we can figure out someones heart rate. This testing was important because it helped us make sure that our system works and it helped us find problems before we started using the hardware.

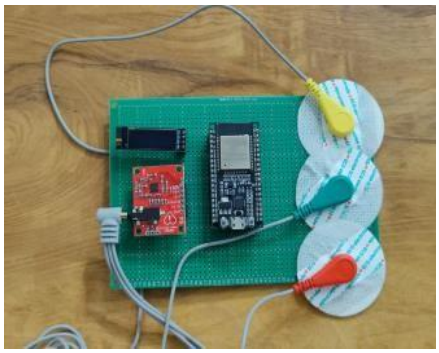

Fig -1: Model Diagram

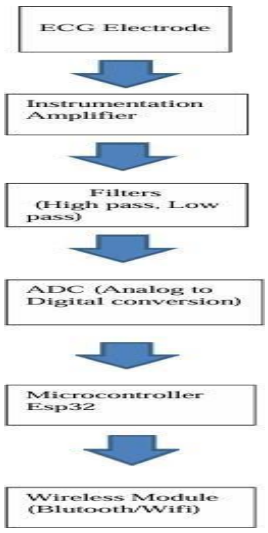

Fig 2- Block Diagram

4. RESULT

The real-time ECG monitoring system design was finished. This system was able to get ECG signals from the AD8232 sensor module. Then use the ESP32 microcontroller to work with these signals. The ECG signal we got was stable. Did not have any noise after we made it stronger and cleaned it up. The ESP32 microcontroller changed the ECG signal from analog to digital using its ability to do this. Then it sent the ECG signal to other devices using Bluetooth and Wi-Fi. We were able to get this signal on an application or a cloud service and see what was happening in real time. This system was also able to show the ECG waveform on a screen that people could understand. It found the heart rate by looking at the peaks on the ECG waveform. Showed how many beats per minute the heart was making. We used the Wokwi platform to test if the system could make waveforms draw them and send them wirelessly and it worked. The real-time ECG monitoring system is good at getting ECG signals sending them in time and letting people monitor them. This is really useful for healthcare when people are not in the place. The time ECG monitoring system is great, for remote healthcare because it can do all these things.

5. CONCLUSIONS

This project shows how to make a real-time ECG moni toring system that can talk to devices. The ECG monitoring system uses the AD8232 ECG sensor and the ESP32 micro controller. This system is made to monitor heart activity all the time in a way that's easy to carry and not too expensive. The ECG monitoring system gets signals from electrodes that people wear. These signals are made stronger. Cleaned up by the AD8232 chip. The ESP32 microcontroller changes the ECG signal into form and lets the system talk to other devices using Bluetooth and Wi-Fi. Then the ECG signal shows up in time on a mobile phone app or website and it also calculates the heart rate. The ECG monitoring system is better than the systems used in hospitals because it is easy to move simple to use and can be monitored from far away. This system is really helpful for doctors who see patients from away and for patients who live in rural areas and do not have easy access, to hospitals. The tests we did show that the ECG monitoring system can really help people get the care they need and find heart problems early. The ECG monitoring system is an example of how Internet of Things technology can be used to make medical care better.

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