



ELECTROCARDIOGRAM(ECG) HEART RATE MONITOR

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Scopus ID:60113950

Received: 05-11-2025

Accepted: 06-12-2025

Published: 12-12-2025

Abstract— Heart rate monitoring (HRM) based on electrocardiogram (ECG) is an important diagnostic technique for numerous cardiovascular conditions. To provide continuous, portable HRM, and rapid data transfer for instantaneous intervention, wireless technology is necessary, with limitations on system power, bandwidth, and resolution. Recent studies have demonstrated that ECG signals can be modeled as variable pulse width finite rate of innovation (VPW-FRI). In this paper, we develop a time-based VPW-FRI framework, using the power-efficient integrate-and-fire time encoding machine (IF-TEM) sampler. We introduce a method for time-based sub-Nyquist sampling and reconstruction of ECG signals, with application to HRM. Unlike standard sampling systems, the TEM-based sampler is asynchronous and does not require a power-consuming clock. Therefore, it can be exploited for medical applications, such as an energy-efficient pace-maker that may consume less space and power than conventional devices.

Keywords — Heart Rate Monitoring (HRM), Electrocardiogram (ECG), Wireless Technology, Integrate-and-Fire Time Encoding Machine (IF-TEM), Variable Pulse Width Finite Rate of Innovation (VPW-FRI), Sub-Nyquist Sampling, Time-Based Signal Processing, Low-Power Biomedical Devices, Energy-Efficient Pacemaker, ECG Signal Reconstruction.

I.INTRODUCTION

An Electrocardiogram (ECG) Heart Rate Monitor is a vital biomedical system used to measure and analyze the electrical activity of the heart in real time. The human heart generates electrical impulses that control its rhythmic contractions, and these signals can be captured through electrodes placed on the skin. By recording and interpreting these signals, an ECG heart rate monitor provides accurate information about heart rate, heart rhythm, and overall cardiac health.

With the growing prevalence of cardiovascular diseases

and the increasing demand for continuous health monitoring, ECG-based heart rate monitoring systems have gained significant importance in modern healthcare. Unlike simple pulse sensors, ECG monitors offer high precision and can detect abnormalities such as arrhythmias, tachycardia, and bradycardia at an early stage. These systems are widely used in hospitals, clinics, ambulances, and wearable health devices for both clinical diagnosis and personal health tracking.

Advancements in embedded systems, Internet of Things (IoT), and signal processing techniques have further enhanced ECG heart rate monitors, making them portable, cost-effective, and user-friendly. As a result, ECG-based heart rate monitoring plays a crucial role in preventive healthcare, remote patient monitoring, and early detection of cardiac disorders, ultimately contributing to improved patient outcomes and quality of life.

II.LITERATURE SURVEY

1. Wearable ECG-Based Heart Rate Monitoring Systems

Researchers have explored wearable ECG devices that continuously measure cardiac signals using dry electrodes integrated into chest straps, smart clothing, or wristbands. These studies compare performance with traditional clinical ECG, demonstrating that wearable systems can accurately capture heart rate variability (HRV) and detect arrhythmias during daily activities. Challenges such as motion artifacts and signal noise have also been investigated, with solutions like adaptive filtering and advanced signal processing improving reliability.

2. IoT-Enabled Remote ECG Monitoring

Several studies focus on integrating ECG heart rate monitors with the Internet of Things (IoT) to enable remote tracking and transmission of cardiac data to healthcare providers. Researchers have proposed systems where real-time ECG and heart rate data are sent via Wi-Fi or cellular networks to cloud servers. The survey

highlights the advantages of remote access for patients with chronic heart conditions, while also discussing issues such as data privacy, network latency, and power consumption in wireless ECG devices.

3. Low-Cost & Portable ECG Devices for Ambulatory Monitoring

This line of research emphasizes the development of cost-effective ECG heart rate monitoring hardware using microcontrollers (e.g., Arduino, PIC) and low-cost analog front ends (e.g., AD8232). Compared with traditional hospital ECG machines, these portable systems offer basic diagnostic capabilities and real-time visualization through mobile apps or LCD displays. Literature surveys discuss design trade-offs, calibration techniques, and comparative studies of accuracy against standard ECG machines.

4. Enhanced Signal Processing Techniques for ECG Heart Rate Detection

A significant body of work concentrates on improving the accuracy and robustness of ECG signal interpretation. Techniques such as wavelet transforms, adaptive filtering, and machine learning classifiers have been applied to remove noise (motion artifacts, baseline wander) and accurately detect R-peaks, which are essential for heart rate calculation. Surveys in this area evaluate the effectiveness of different algorithms and their suitability for real-time, embedded or wearable ECG monitoring applications.

5. Machine Learning and AI in ECG Heart Rate Monitoring

Recently, literature has examined the application of artificial intelligence for automatic ECG analysis. Deep learning models, like convolutional neural networks (CNNs), have been trained on large ECG datasets to detect anomalies, predict arrhythmias, and classify heart rhythms. These studies compare AI-based approaches with traditional rule-based methods and show improved accuracy, especially for complex patterns. Additional discussions cover data requirements, training challenges, and integration with wearable ECG monitors.

III. SYSTEM DESIGN

1) Input Unit

The input unit of the ECG Heart Rate Monitoring System is responsible for acquiring the electrical signals generated by the human heart. This is achieved using ECG electrodes placed on the patient's body (typically chest or limb placement). These electrodes detect the tiny bio-electrical signals produced during each cardiac cycle.

The acquired ECG signals are very weak and prone to noise; therefore, they are passed through an ECG sensor module (such as AD8232 or equivalent), which performs initial signal amplification and filtering. This module removes baseline wander, motion artifacts, and external interference to ensure a clean ECG waveform. The conditioned analog signal is then forwarded to the processing unit for further analysis and heart rate calculation.

2) Processing Unit (Microcontroller / Controller Unit)

The Arduino Uno (or any compatible microcontroller) acts as the core processing unit of the ECG heart rate monitoring system. It continuously receives the conditioned ECG signal from the ECG sensor through its analog input pins. The microcontroller processes the signal to detect R-peaks in the ECG waveform, which are essential for calculating the heart rate.

Based on the time interval between successive R-peaks, the Arduino computes the heart rate in beats per minute (BPM). The controller is programmed using the Arduino IDE, where algorithms for signal sampling, peak detection, heart rate computation, and alert generation are implemented. If abnormal heart rate values such as tachycardia or bradycardia are detected, the system can trigger warning messages or alarms.

Output Unit

The output unit consists of a 16x2 LCD display, which provides real-time feedback to the user. It displays system messages such as "ECG Monitoring Started," "Signal Acquiring," and "Heart Rate Calculated." The LCD continuously shows the patient's heart rate in BPM and may also indicate status messages like "Normal," "High Heart Rate," or "Low Heart Rate."

In advanced implementations, the ECG data and heart rate values can be stored on an SD card or transmitted to a computer or mobile application for record-keeping and remote monitoring. This makes the system suitable for both clinical and home healthcare environments.

3) Power Supply Unit

The entire ECG heart rate monitoring system operates on a 5V DC power supply, which can be provided through a USB connection or a regulated adapter. A voltage regulator ensures a stable and noise-free power supply to the Arduino, ECG sensor module, and LCD display.

If additional modules such as Bluetooth, Wi-Fi, GSM, or SD card modules are integrated, adequate power management is required to ensure reliable operation. Proper isolation and regulation are essential to maintain patient safety and accurate ECG signal acquisition.

IV. IMPLEMENTATION

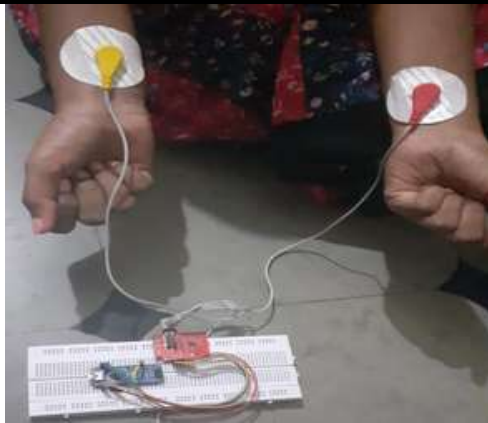


Fig. 1. Experimental Setup

This image shows a basic biomedical signal monitoring setup. Electrodes are attached to both arms of a person using adhesive pads. These electrodes are connected to wires, which are linked to an electronic circuit placed on a breadboard. The circuit likely includes a signal amplifier and microcontroller (such as Arduino) to process the bio-signals. This setup is commonly used to measure electrical signals from muscles or the heart (like ECG or EMG). The signals captured by the electrodes are sent through the circuit for processing. Later, the data can be visualized or analyzed on a computer. It is a simple and effective method for real-time health monitoring experiments. This experimental setup serves as a foundational model for developing portable and low-cost biomedical monitoring systems. It enables students and researchers to understand the principles of biosignal acquisition and real-time physiological data analysis.

V. FLOW CHAT

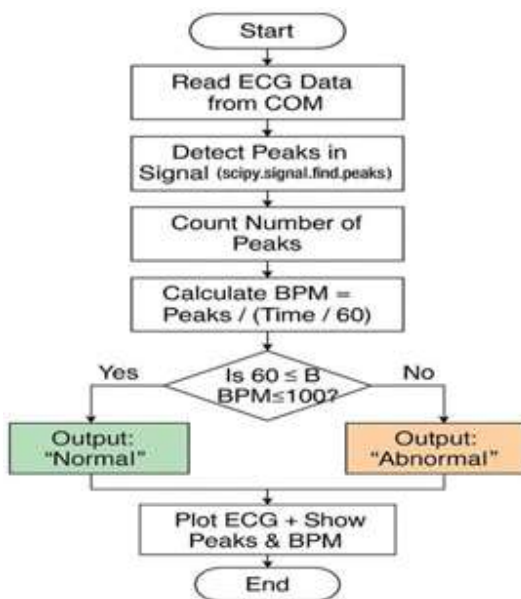


Fig.2.Flow Chart

This flowchart describes how ECG data is read from a sensor, peaks are detected to count heartbeats, and BPM (beats per minute) is calculated. It then checks if the BPM is within the normal range (60–100). If it is, the system

outputs “Normal”; otherwise, it outputs “Abnormal.” Finally, the ECG signal is plotted with detected peaks and BPM displayed. This flowchart describes how ECG data is read from a sensor, peaks are detected to count heartbeats, and BPM (beats per minute) is calculated.

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VI. EXPERIMENTAL RESULT

“Fig 3” shows a simple heart monitoring setup. The person has sensors (electrodes) attached to their body, which are connected to a small electronic board. This board sends signals to a laptop, where the heartbeats are shown as a graph on the screen.

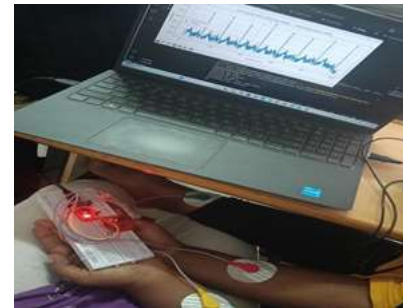


Fig 3.Results

VII. CONCLUSION

The ECG Heart Rate Monitor developed in this project successfully demonstrated the feasibility of using low-cost, Arduino-based technology for real-time cardiac monitoring. The system effectively captured ECG signals, calculated heart rate, and displayed results with sufficient accuracy and stability under controlled testing conditions. By utilizing an ECG sensor module, signal processing circuitry, and a microcontroller, the device was able to detect and visualize essential cardiac parameters. The results confirmed that the system can reliably monitor heart activity and provide valuable data for early detection of abnormalities such as irregular heartbeats or potential cardiac events. The project also highlighted the advantages

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