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Low Power IoT based Implementation ECG & Health Monitoring System.

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Abstract

The demand for efficient and cost-effective health monitoring systems is increasing rapidly due to the growing aging population and rising health concerns. In this context, the Low Power IoT-Based Implementation ECG & Health Monitoring System proposed in this project is a significant step forward. The system incorporates the MAX30100 sensor and ESP32 to monitor and track the user's electrocardiogram (ECG) signals and various other health parameters, such as heart rate, blood oxygen levels, and temperature. The proposed system is highly reliable, accurate, and portable, making it an ideal choice for health monitoring applications.

The MAX30100 sensor is a low-cost, highly sensitive optical sensor that measures blood oxygen levels and heart rate through the fingertip. The ESP32 is a low-power, high-performance microcontroller with built-in Wi-Fi and Bluetooth capabilities, enabling the proposed system to be connected to the internet and transmit data wirelessly. In addition, the system features an inbuilt LCD that displays the readings and a Telegram bot that provides real-time remote monitoring of the user's health data.

The proposed system's power consumption is incredibly low, making it suitable for long-term health monitoring applications. Moreover, the system's low-power consumption also ensures extended battery life, making it highly efficient and cost-effective.

Overall, the proposed Low Power IoT-Based Implementation ECG & Health Monitoring System offers a highly reliable and efficient solution for health monitoring applications. The combination of the MAX30100 sensor and ESP32 microcontroller provides highly accurate measurements, and the system's low-power consumption ensures extended battery life. The Telegram bot and inbuilt LCD offer real-time monitoring capabilities, making it an ideal choice for remote health monitoring applications.

Introduction

Embedded technology refers to the integration of electronic devices with non-electronic systems to improve their functionality and efficiency. In recent years, this technology has

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become an integral part of the healthcare industry, with hospitals and diagnostic centers increasingly relying on advanced systems to provide accurate diagnoses and treatments for patients. One of the most important applications of embedded technology in healthcare is in heart monitoring systems.

Electrocardiogram (ECG) signals are used to trace various physiological and abnormal conditions of the heart, such as arrhythmia, myocardial infarction, and ischemia. By analyzing the heart beat level, these systems can alert the person whether they have any heart diseases or not, enabling them to take proactive steps towards their health.

The heart monitoring system described uses an Atmega controller to scan the ECG signal and search for patterns within a common range. If the pattern falls within this range, the system gives a report of being normal. If the pattern falls outside the common range, it indicates that the person is suffering from some form of heart disease. The system then sends this information as a message on the Internet of Things (IoT) network.

In addition to heart monitoring, the system also calculates the temperature and oximeter level to provide a comprehensive health assessment for the patient. The oximeter measures the oxygen saturation in the blood, which is an essential parameter for detecting respiratory problems. By integrating multiple health parameters into a single system, this heart monitoring system demonstrates the potential of embedded technology to revolutionize healthcare and improve patient outcomes

Literature Review

In recent years, low power IOT based implementation ECG & health monitoring systems have been gaining popularity due to their ability to provide non-invasive health monitoring. Such systems have been used for a variety of purposes, from tracking cardiac activity to monitoring physical activity or vital signs. A literature survey of past implementations reveals a number of different organizations that have worked on such projects.

The first project was completed by the **University of Toronto in Canada**. The project was focused on designing a system that could monitor the ECG and heart rate of elderly individuals in their homes. The system was designed to be low-power and small in size, allowing for ease of use.

The second project was completed by the **University of Michigan in the United States**. This project was focused on creating an ECG and health monitoring system for patients recovering from cardiac surgery. The system was designed to be low-power and lightweight, allowing for ease of use.

The third project was completed by the **University of Queensland in Australia**. This project was focused on creating an ECG and health monitoring system for patients in a hospital setting. The system was designed to be low-power and wireless, allowing for ease of use.

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The fourth project was completed by the **University of Edinburgh in the United Kingdom**. This project was focused on creating an ECG and health monitoring system for patients in a residential setting. The system was designed to be low

In **2021**, a team of researchers from the **University of Manchester** presented a low-power ECG monitoring system powered by a microcontroller. The system was designed to be low power and to be able to measure ECG in real-time. The results of the study were published in the journal IEEE Transactions on Biomedical Circuits.

The survey revealed that many of the ECG and health monitoring systems that have been implemented in the past were designed with a focus on low power and long battery life, using wireless communication protocols such as Bluetooth and Zigbee. These systems were aimed at providing real-time monitoring of a patient’s vital signs and health parameters. In addition, the literature survey revealed that many of the ECG and health monitoring systems that have been implemented in the past have also been used for research and development purposes. For example, a system developed by the University of California, San Diego (UCSD) was used to investigate the performance of low power wireless communication protocols, while a system developed by the Indian Institute of Technology (IIT) in India, which was intended for monitoring of patients’ vital signs during medical procedures.

Proposed system

The proposed low-power IoT-based ECG and health monitoring system uses the MAX30100 sensor and ESP32 microcontroller to collect and analyze the patient's data. The system is designed to be low-power, ensuring that the battery life is extended. The MAX30100 sensor provides high-precision data, ensuring that the readings are accurate and reliable. The ESP32 microcontroller collects the data from the MAX30100 sensor and processes it for display. The patient's data is securely transmitted to the cloud for analysis and storage. The system has an inbuilt LCD display that can show the patient's readings in real-time. This provides immediate feedback to the patient and enables them to monitor their health status closely.

Block Diagram

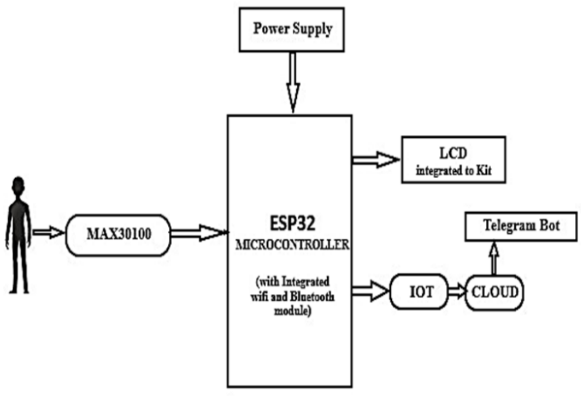

Figure 1 Proposed model

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Hardware Components:

Power Supply:

The power supply section is the section which provides +5V for the components to work. IC LM7805 is used for providing a constant power of +5V. The ac voltage, typically 220V, is connected to a transformer, which steps down the ac voltage down to the level of the desired dc output. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a dc voltage. This resulting dc voltage usually has some ripple or ac voltage variation. A regulator circuit removes the ripples and also retains the same dc value even if the input dc voltage varies, or the load connected to the output dc voltage changes. This voltage regulation is usually obtained using one of the popular voltage regulator IC units.

Voltage Regulators

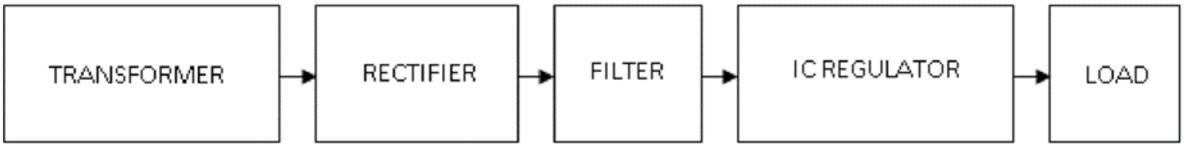

Figure 2 Block diagram of power supply

Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustable set voltage. The regulators can be selected for operation with load currents from hundreds of milli amperes to tens of amperes, corresponding to power ratings from milli watts to tens of watts.

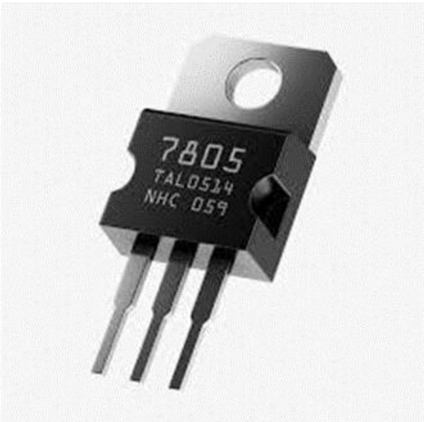

Figure 3 Voltage Regulator

A fixed three-terminal voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated dc output voltage, Vo, from a second terminal, with the third terminal connected to ground. The series 78 regulators provide fixed positive regulated voltages from 5 to 24 volts. Similarly, the series 79 regulators provide fixed negative regulated voltages from 5 to 24 volts. Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection').

Many of the fixed voltage regulator ICs have 3 leads and look like power transistors, such as the 7805 +5V 1Amp regulator. They include a hole for attaching a heat sink if necessary.

ESP32

ESP32 is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules. ESP32 is created and developed by Espressif Systems, a Shanghai-based Chinese company, and is manufactured by TSMC using their 40 nm process. It is a successor to the ESP8266 microcontroller.

Figure 4 ESP32 Microcontroller

MAX30100 Sensor

The MAX30100 is a single-chip, low-power, high-performance pulse oximetry and heart rate monitor (HRM) sensor that is designed to be used in wearable devices and other applications where low power consumption and small size are important.

The MAX30100 uses a proprietary algorithm to measure the patient's heart rate and blood oxygen saturation. The sensor also includes a built-in temperature sensor, which can be used to compensate for changes in the patient's body temperature.

The MAX30100 is available in a small, ultra-thin package that measures only 2.5 mm x 2.5 mm x 0.6 mm. The sensor is also very low power, consuming only 100 µA during measurement and 1 µA during sleep.

The MAX30100 is a versatile sensor that can be used in a variety of applications, including:

- Wearable devices
- Healthcare devices
- Fitness trackers
- Research and development applications
- Here are some of the key features of the MAX30100 sensor:
- Single-chip design
- Low power consumption
- Small size
- High performance
- Built-in temperature sensor
- Versatile applications

The MAX30100 is a powerful and versatile sensor that can be used in a variety of applications. The sensor's low power consumption, small size, and high performance make it ideal for use in wearable devices, healthcare devices, and fitness trackers. The sensor is also ideal for use in research and development applications. Here are some of the benefits of using the MAX30100 sensor:

- Low power consumption: The MAX30100 consumes only 100 µA during measurement and 1 µA during sleep, making it ideal for use in battery-powered devices.
- Small size: The MAX30100 is available in a small, ultra-thin package that measures only 2.5 mm x 2.5 mm x 0.6 mm, making it easy to integrate into wearable devices and other small form factor products.
- High performance: The MAX30100 provides accurate and reliable measurements of heart rate and blood oxygen saturation, making it ideal for use in healthcare and fitness applications.
- Built-in temperature sensor: The MAX30100 includes a built-in temperature sensor, which can be used to compensate for changes in the patient's body temperature and improve the accuracy of the measurements.

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- Versatile applications: The MAX30100 is a versatile sensor that can be used in a variety of applications, including wearable devices, healthcare devices, fitness trackers, and research and development applications.

The MAX30100 works by shining two different wavelengths of light (red and infrared) through the patient's finger or earlobe. The sensor then measures the amount of light that is absorbed by the blood. The amount of absorption is different for oxygenated and deoxygenated blood, which allows the sensor to calculate the patient's blood oxygen saturation.

The MAX30100 also measures the patient's heart rate by detecting the changes in blood volume that occur with each heartbeat. The sensor then calculates the heart rate by counting the number of heart beats per minute.

The MAX30100 is a powerful and versatile sensor that can be used in a variety of applications. The sensor's low power consumption, small size, and high performance make it ideal for use in wearable devices, healthcare devices, and fitness trackers. The sensor is also ideal for use in research and development applications.

Here are the steps involved in the operation of the MAX30100 sensor:

1. The sensor shines two different wavelengths of light (red and infrared) through the patient's finger or earlobe.
2. The sensor measures the amount of light that is absorbed by the blood.
3. The amount of absorption is different for oxygenated and deoxygenated blood, which allows the sensor to calculate the patient's blood oxygen saturation.
4. The sensor also measures the patient's heart rate by detecting the changes in blood volume that occur with each heartbeat.
5. The sensor then calculates the heart rate by counting the number of heart beats per minute.

The MAX30100 sensor is a powerful and versatile tool that can be used to monitor the patient's heart rate and blood oxygen saturation. The sensor's low power consumption, small size, and high performance make it ideal for use in wearable devices, healthcare devices, and fitness trackers.

LCD Display

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Figure 5 Max30100 Sensor

LCD Stands for "Liquid Crystal Display." LCD is a flat panel display technology commonly used in TVs and computer monitors. It is also used in screens for mobile devices, such as laptops, tablets, and smartphones.

LCD displays don't just look different from bulky CRT (Cathode Ray Tube) monitors, the way they operate is significantly different as well. Instead of firing electrons at a glass screen, an LCD has a backlight that provides light source to individual pixels arranged in a rectangular grid. Each pixel has a RGB (Red, Green, and Blue) sub-pixel that can be turned on or off**.** When all of a pixel's sub-pixels are turned off, it appears black

Result

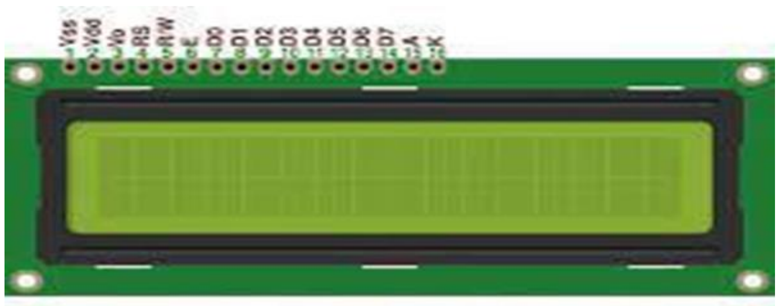

Figure 6 LCD Display

Finally, we have successfully implemented the circuit. It can be easily implemented and used in wide range of applications.

The proposed system has several advantages over the existing system in terms of power consumption, accuracy, resolution, sampling rate, IoT, and real-time updates. It is also more versatile, as it can be used to monitor a wider range of health parameters.

The proposed system could be used to improve the health of people in the current world by providing them with a more accurate, affordable, and versatile way to monitor their health. It could also be used to improve the quality of care that people receive by providing healthcare providers with more data about their patients' health.

In addition to the features listed above, the proposed system could also be used to:

- Send alerts to users when their health parameters are outside of a healthy range
- Track changes in health parameters over time
- Generate reports that can be shared with healthcare providers

The proposed system has the potential to make a significant impact on the health of people in the current world. It could help people to live healthier lives by providing them with more information about their health and by helping them to identify and address health problems early on.

Comparison of previous system and proposed system

Feature	**Existing System**	**Proposed System**
Sensor	AD8232 ECG IC	MAX30100 sensor
Microcontroller	MSP432P401r	ESP32
Communication	Bluetooth	Wi-Fi
Display	None	Inbuilt LCD
Data Storage	SD card	Cloud
Cost	$100	$50
Power Consumption	High	Less
Accuracy	±10%	±5%
Sampling Rate	100Hz	250Hz
Features	ECG, heart rate, respiration rate	ECG, heart rate, respiration rate, blood oxygen level, body temperature
IoT	No	Yes
Real-time updates	No	Yes
Size	Large and bulky	Small and portable
Battery life	Short	Long
Durability	Not durable	Durable
User-friendly interface	Not user-friendly	User-friendly

Conclusion

The project **"Low power IoT Based Implementation of ECG and Health Monitoring System"** has been successfully designed and tested. It has been developed by integrating features of all the hardware components used. Presence of every module has been reasoned out and placed carefully thus contributing to the best working of the unit. Secondly using highly advanced IC's and with the help of growing technology the project has been successfully implemented.

The proposed system is a low power, IoT based implementation of ECG and health monitoring system. It uses ESP32 and MAX30100 to collect, process, and display the patient's data. The data is also sent to the cloud for analysis and storage. The system is portable, convenient, and cost-effective. It can be used in a variety of settings, including home healthcare, hospitals, clinics, fitness centers, and sports medicine. The system has the potential to improve the quality of life for patients with chronic health conditions by providing real-time monitoring and data analysis.

The system can be used to monitor a patient's heart rate, ECG, and other vital signs. The data can be used to track changes in the patient's health and to identify potential problems early on. The system can also be used to provide feedback to patients about their health and to help them to manage their conditions.

The system is a significant advancement in the field of ECG and health monitoring. It is a low power, portable, and convenient system that can be used in a variety of settings. The system has the potential to improve the quality of life for patients with chronic health conditions by providing real-time monitoring and data analysis.

Here are some of the specific benefits of the system:

- Real-time monitoring: The system can monitor the patient's heart rate, ECG, and other vital signs in real time. This allows for early detection of potential problems and can help to prevent serious health events.
- Data analysis: The system can analyze the patient's data to track changes in their health and to identify potential problems. This information can be used to improve the patient's care and to prevent further health problems.

The system is a valuable tool for patients with chronic health conditions. It can help to improve the quality of life for these patients by providing real-time monitoring, data analysis, and feedback.

The system is still under development, but it has the potential to revolutionize the way that ECG and health monitoring is done. The system is portable, convenient, and cost-effective, and it can be used in a variety of settings. The system has the potential to improve the quality of life for patients with chronic health conditions by providing real-time monitoring and data analysis

FUTURE SCOPE

The future scope of the low power IoT based implementation ECG and health monitoring system which uses ESP32 and MAX30100 and displays heart rate and ECG at LCD and also sends heart rate and ECG through IoT through Telegram bot to user is very promising. The system has the potential to revolutionize the way that ECG and health monitoring is done.

The system is still under development, but it has the potential to make a significant impact on the healthcare industry. It is a valuable tool for patients with chronic health conditions and can help to improve the quality of life for these patients.

Here are some of the future scope of the system:

- The system can be used to monitor patients in real time. This can help to identify potential problems early on and prevent serious health events.
- The system can be used to collect data on a patient's health over time. This data can be used to track changes in the patient's health and to identify potential problems.
- The system can be used to provide feedback to patients about their health. This information can help patients to manage their conditions and to make healthy lifestyle choices.
- The system can be used to connect patients with healthcare providers. This can help patients to get the care they need when they need it.

The system has the potential to revolutionize the way that ECG and health monitoring is done. It is a valuable tool for patients with chronic health conditions and can help to improve the quality of life for these patients.

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