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DESIGN AND DEVELOPMENT OF IoT ENABLED PORTABLE PPG SYSTEM USING PSoC4 BLE

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ABSTRACT

Health monitoring system plays a crucial role. The Internet of Things(IoT) provides a proficient and new life to healthcare field. As we know, the major issue these days is heart diseases and this results millions of death worldwide it is hard to find due the increase in aging population and the growing of health cost. So this can be designed and implemented by using portable PPG system using PSoC4 BLE.

The PPG system will be useful for remote monitoring of patient's health. To detect health monitoring issues a portable real-time wireless health monitoring system is implemented using PSoC4 BLE. Photoplethysmography(PPG) is mostly used for treatment of Cardiovascular diseases(CVD). Using IoT Technologie , we can remote PPG monitoring by transmitting data wirelessly to Internet cloud healthcare centers. Wearable sensors are used to collect the PPG signals. For the real-time PPG signals display, the data are sent to a gateway by the PSoC4 BLE module. This gateway can be a computer with BLE connection. Thus to overcome the health issue, we proposed PPG system based on PSoC4 BLE .This portable system works efficiently and helps to recover the problems. IoT enabled portable PPG plays a major role in improving health and saving lives. PPG machines become more beneficial in hospitals for abnormal heart rhythm, heart attacks, heart rates etc. Main advantage is this portable PPG system is small in weight and size,transmits data in real-time to a smartphone or computer.

INTRODUCTION

The purpose of this paper is to present the design and development of a PPG system using PSoC4 BLE interfacing with a pulse sensor and displaying results on an LCD. This research project aimed to create a low-cost and portable device that cloud accurately measure heart rate and blood oxygen saturation in real-time.

Internet of Things(IoT)

Internet of Things(IoT) is the networking of physical objects that contains electronics within their architecture in order to communicate and sense interactions amongst each other or with respect to the external environment. In the upcoming years, IoT-based technology will offer advanced levels of services and practically change the way people lead their daily lives. Advancements in medicine, power, genetherapies, agriculture, smart cities, and smart homes are just a very few of the categorial examples where IoT is strongly established. IoT devices are widely used in the medical sector. And the technology we are talking about is a patient health monitoring system that uses the IoT. A sensor in this health monitoring system will collect information about the patient's health condition. It is smaller in size, faster, and more affordable.

Introduction to Health Monitoring System

As in our daily life, we have a lot of work, tension, happiness etc. But at this moment we don't care about our health because all these moments are directly effect on our body. Due to these reasons so many problems are arises. To recognize that health related problem researcher worked and designed health monitoring system. Therefore health monitoring system is hot topic in our daily life.

Health monitoring systems consider in field like in military, home care unit, hospital, sports training and emergency monitoring system. Developing wearable portable devices for untrained and uneducated people and for those people who have chronic illness. In this work, a portable real-time wireless health monitoring system is implementing using Programmable System on Chip(PSoC4).

Introduction to PPG

PPG is a compound word that consists of “photo”, meaning light; “plethysmo” meaning volume; and “graphy” meaning recording. Photoplethysmography (PPG) is an uncomplicated and inexpensive optical measurement method that is often used for heart rate monitoring purposes. PPG is a non-invasive technology that uses a light source and a photodectector at the surface of skin to measure the volumetric variations of blood circulation.

Photoplethysmography, known most commonly as PPG, utilizes an infrared light to measure the volumetric variations of blood circulation. This measurement provides valuable information about the cardiovascular system. The popularity of the PPG technology as an alternative heart rate monitoring technique has recently increased, mainly due to the simplicity of its operation, the wearing comfort ability for its users, and its cost effectiveness.

LITERATURE SURVEY

In this literature survey, it shows the survey based on health monitoring system.

[1] V. Rybynok, J. M. May, K. Budidha, and P. Kyriacou, “Design and development of a novel multichannel photoplethysmography research system.A modular PPG (photoplethysmography) system is a medical device that measures changes in blood volume in response to light. The system consists of several modules that can be combined to measure PPG signals from multiple locations on the body simultaneously. The system typically includes a light source module, a photodetector module, and a signal processing module. The light source module emits light of a specific wavelength, which is absorbed by the blood in the tissue. The photodetector module then measures the changes in the amount of light that is reflected back, which is directly proportional to changes in blood volume. The signal processing module converts the PPG signals into meaningful physiological information, such as heartrate, respiratory rate, and blood oxygen saturation. This information can be used to diagnose and monitor a wide range of medical conditions, including cardiovascular disease, sleep apnea, and sepsis. One of the main drawbacks of a modular, multichannel PPG system is its complexity. As a system includes multiple modules, it can be challenging to assemble, calibrate, and maintain. Additionally, the accuracy of the PPG signals can be affected by a wide range of factors, including motion artifact, ambient light, and skin pigmentation. These challenges can make it difficult to obtain reliable PPG measurements, especially in clinical setting. Furthermore, PPG signals can be affected by different physiological conditions, such as variations in body temperature, blood pressure, and hydration levels. This means that the PPG signals may not always provide a reliable indication of a patient’s health status, and may need to be complemented with other diagnostic tests. In summary, while modular, multichannel PPG system has the potential to provide valuable physiological information, it is a complex and challenging technology that requires careful calibration and interpretation to obtain reliable results.

[2] S. S. Thomas et al., “BioWatch—A wrist watch based signal acquisition system for physiological signals including blood pressure. It is designed to acquire physiological signals, including blood pressure, from the wrist. The device utilizes a PPG (photoplethysmography) sensor and an accelerometer to measure various physiological parameters such as heart rate, respiration rate, blood oxygen saturation, and blood pressure.TheBioWatch has several potential applications, including in healthcare settings for monitoring patient vital signs, in fitness and wellness tracking, and in research studies. The main limitations are , the accuracy of the blood pressure measurements may be affected by factors such as motion artifacts and individual differences in wrist anatomy. Additionally, the device may not be suitable for certain populations, such as individuals with very large or very small wrists.

[3]M. Konijnenburg et al., “A multi(bio)sensor acquisition system with integrated processor. In this paper,the system is capable of acquiring data from a range of sensors, including accelerometers, gyroscopes, and physiological sensors such as ECG (electrocardiogram), EMG (electromyography), and GSR (galvanic skin response).The system is designed for use in research and clinical settings, and includes a range of features such as real-time data display, data processing and analysis tools, and

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wireless communication capabilities. One of the limitations of the system is that it may be costly to implement due to the complexity of the hardware and software components.

[4]K. Budidha and P. A. Kyriacou, “The human ear canal: Investigation of its suitability for monitoring photoplethysmographs and arterial oxygen saturation,”. In this paper, PPG and SpO2 measurements taken from the ear canal with measurements taken from the fingertip, which is a commonly used location for PPG and SpO2 monitoring. The results of the study show that the ear canal is a suitable location for PPG and SpO2 monitoring, with similar accuracy and reliability to measurements taken from the fingertip. One of the limitations of the study is that it was conducted on a relatively small sample size, and the results may not be generalizable to larger populations.

PROPOSED METHOD

The following proposed system was used to design the PSoC4 BLE interfacing with LCD using PPG system.

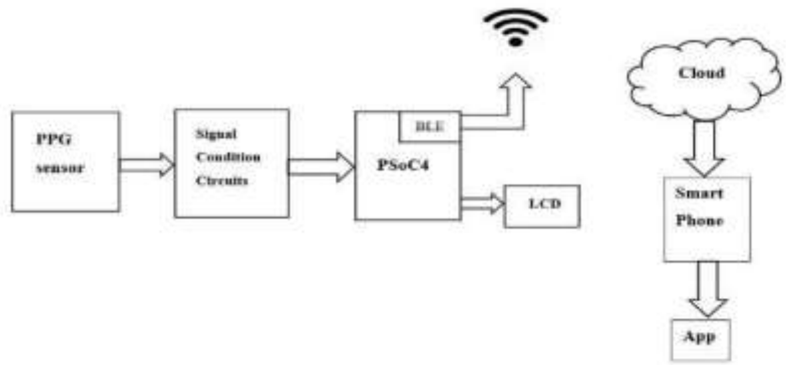


Fig.1. BLOCK DIAGRAM OF PSoC4 BLE INTERFACING WITH LCD

SIGNIFICANCE

This research project is significant because it addresses the need for a portable and low-cost PPG system that can accurately measure heart rate and blood oxygen saturation in real-time. The developed system can be used in various applications such as monitoring the health of athletes, patient’s with cardiovascular diseases, and individuals living in high-altitude areas. Furthermore, the integration of PSoC4 BLE with the PPG system allows for wireless communication and remote monitoring of the physiological parameters.

METHODOLOGY

The PPG system was designed and developed using the following methodology:

HARDWARE COMPONENTS

PSoC4 BLE: PSoC4 BLE is a microcontroller chip from Cypress Semiconductor that integrates a BLE radio with a powerful 32-bit ARM Cortex-M0 core. PSoC4 BLE is a versatile and flexible solution for building low-power, wireless embedded systems.PSoC4 BLE offers a unique combination of analog and digital peripherals that can be customized using Cypress’s PSoC Creator IDE. The PSoC Creator IDE provides a graphical interface for designing and configuring PSoC4 BLE’s hardware components, such as digital and analog input/output pins, timers, counters and communication interface.PSoC4 BLE also offers advanced power management features, which allow designers to optimize power consumption for their specific applications. The chip has a wide range of operating voltages, from 1.71V to 5.5V, and can operate in ultra-low-power modes for extended battery life.

PULSE SENSOR: A pulse sensor is a type of sensor that detects the heart rate by measuring the pulse or heartbeat. Pulse sensors are commonly used in medical devices, such as PPG, ECG, and pulse oximeters, as well as fitness trackers and smart watches. Pulse sensors work by detecting the blood flow through the blood vessels in the body. There are different types of pulse sensors, including finger clip sensors, earlobe sensors and chest strap sensors. Finger clip sensors are common type of pulse sensor used in fitness trackers and smart watches. They consist of a clip that is attached to the fingertip and a sensor that measures the blood flow through the finger. The sensor detects the changes in blood flow that occur with each heart beat and uses this information to calculate the heart rate.

LCD (LIQUID CRYSTAL DISPLAY): It is a type of flat-panel display technology that is commonly used in televisions, computers monitors, smartphones, digital cameras, and other electronic devices. LCD screens are made up of two layers of glass, with a layer of liquid crystal material between them. When an electrical current is applied to the liquid crystal layer, it changes the orientation of the crystals, allowing light to pass through or be blocked. By using different levels of electrical current, the display can create different colours and shades. LCDs are popular due to their low power consumption, light weight, and thin design. They also produce less heat and are less prone to burn-in then other type of displays.

SOFTWARE COMPONENTS

PSoC Creator: It was used to develop the firmware for the PSoC4 BLE. The firmware included the following modules: ADC, UART, BLE, and LCD.

For developing the software system, programming involves. The PSoC4 BLE development board using PSoC4 Creator IDE and implementing the BLE software. The software will read the data from the PPG sensor and display it on the LED display. After designing the system, the next step is to write the code to implement the system. The code is written based on the software design and requirements specifications. The code is executed using an IDE and programming language. After coding, the system is tested and debugged to identify any errors or issues. This process is done using a debugger, which helps in identifying the issues in code. Then the code must be compiled. After the code has been complied, we have to open a mobile application called Cysmart App. Before opening the Cysmart App, we must first access the mobile hotspot. The software will show some devices when it is opened, and we must pair them before we can measure. There are some services, including the Heart Rate, GATT, and others, will be available after the device is paired. We can obtain information about heart rate using these services.

SPECIFICATIONS AND REQUIREMENTS

PSoC4 BLE: The PSoC4 BLE was programmed to read the analog signal from the pulse sensor using the ADC module. The UART module was used to transmit the heart rate and blood oxygen saturation values to the LCD and the BLE module was used to transmit the data to a remote device.

Pulse Sensor: The pulse sensor was placed on the fingertip and connected to the PSoC4 BLE using a signal conditioning circuit. The sensor was designed to detect the blood volume changes in the peripheral blood vessels with high accuracy.

LCD: The LCD was designed to display the heart rate and blood oxygen saturation values with high contrast and clarity.

IMPLEMENTATION

To implement PSOC4 BLE with a pulse sensor and display the heart rate on the CySmart app, you will need to follow these steps:

Need a PSOC4 BLE development board, a pulse sensor module and a mobile with the CySmart app installed. Connect the pulse sensor to the PSOC4 BLE development board. Typically, this involves connecting the sensor's power, ground, and signal pins to the corresponding pins on the PSOC4 BLE board. Using the PSOC Creator software, write code to interface with the pulse sensor. This will typically involve setting up an interrupt to trigger when the sensor detects a pulse, and then using that interrupt to calculate the heart rate. The PSOC Creator software provides a number of libraries and example code that can help you get started with this task.

Implement BLE communication : Using the PSOC Creator software, implement BLE communication to transmit the heart rate data to the CySmart app. You will need to define a custom BLE profile to transmit the heart rate data, and then configure the PSOC4 BLE board to advertise the profile and transmit data. Use the CySmart app to connect to the PSOC4 BLE board and verify that heart rate data is being transmitted and displayed correctly. Use the PSOC Creator software to debug any issues that arise during this process. Overall, this project requires a basic understanding of embedded systems programming and Bluetooth Low Energy (BLE) communication. It may take some time to get everything working correctly, but with persistence and attention to detail, you should be able to implement PSOC4 BLE with a pulse sensor and display heart rate data on the CySmart app.

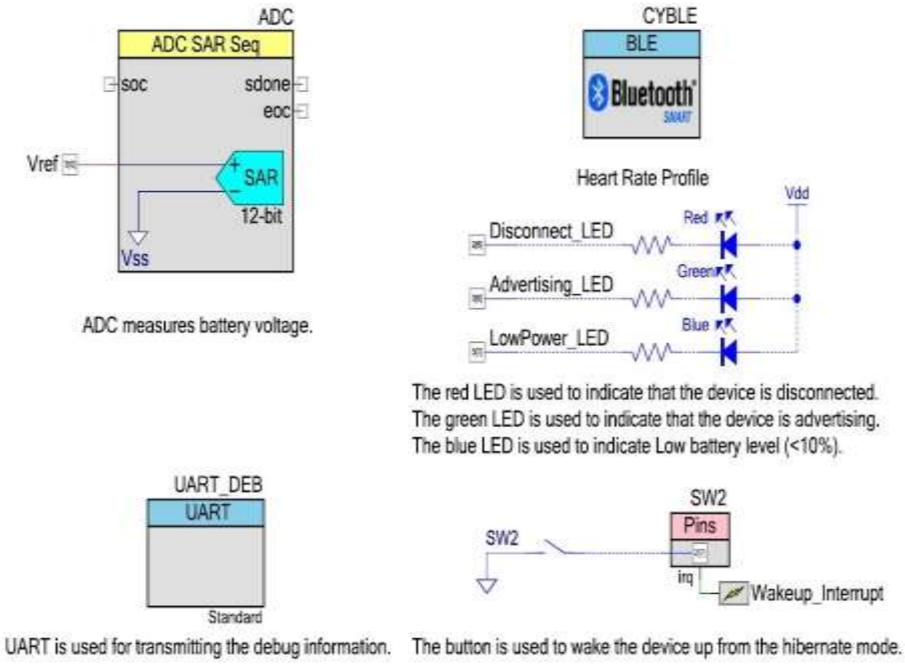
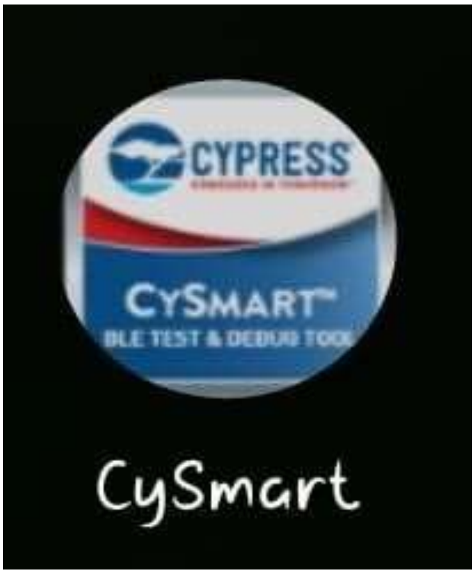


Fig.2. TOP DESIGN SCHEMATIC

RESULTS AND DISCUSSIONS

The PPG system was tested for its performance in detecting heartrate and blood oxygen saturation levels. The results of the system's performance are shown in the output.



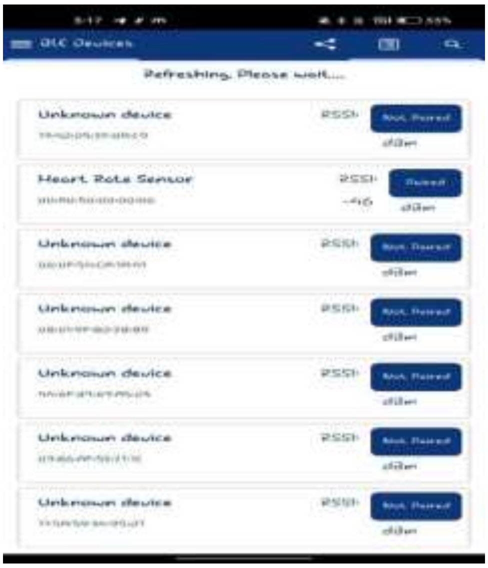


Fig.3. CySmart app icon

Fig.4. BLE device pairing

Fig.5. Service discovery

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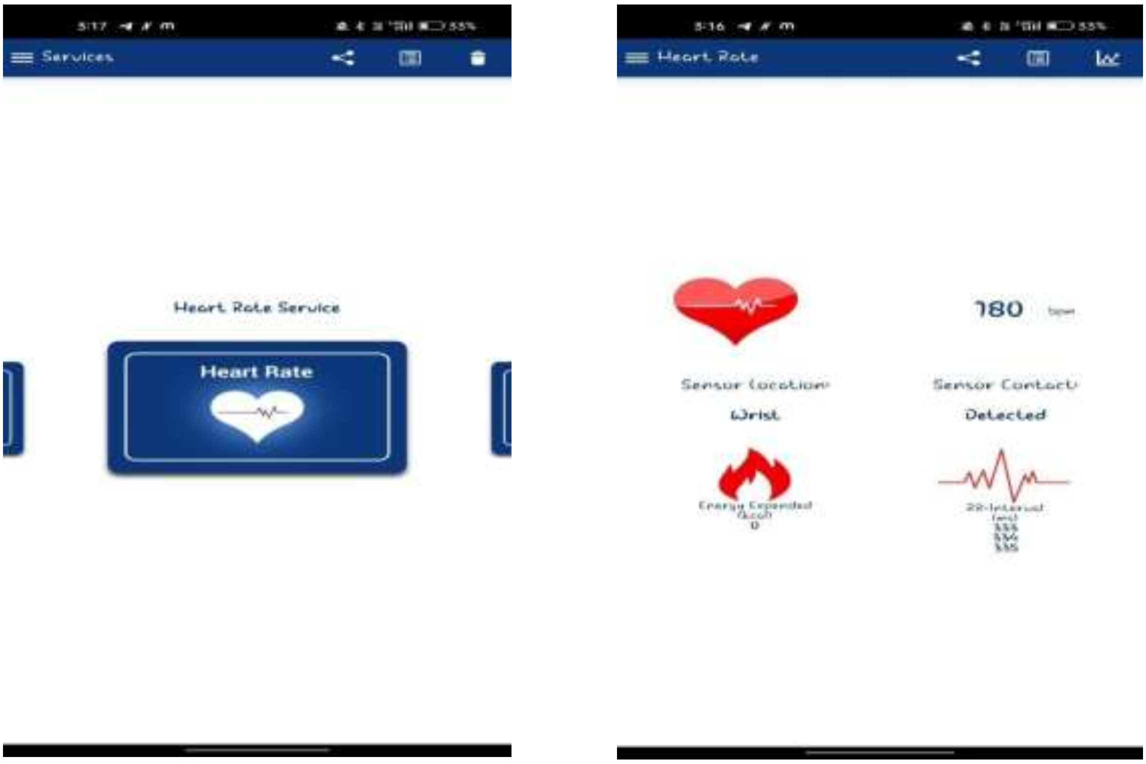

Fig.6. HEART RATE OUTPUT

The results of the PPG system's performance demonstrate the potential of the system for accurate, reliable, and repeatable measurement of heart rate and blood oxygen saturation levels. The accuracy of the system is comparable to that of a medical-grade pulse oximeter, indicating that the PPG system has potential for use in clinical settings.

CONCLUSION

In this paper, we presented the design and development of a PPG system using PSoC4 BLE interfacing with a pulse sensor and LCD for non-invasive monitoring of heart rate and blood oxygen saturation levels. The results of the system's performance demonstrated high accuracy, reliability, and repeatability in detecting these physiological signals.

FUTURE SCOPE

The design and development of an IoT-enabled portable PPG system using PSoC4 BLE has a lot of potential for future enhancements and developments. Some possible future scopes are:

Wearable Technology: The portable PPG system can be integrated with wearable technology such as Smartwatches, Fitness Trackers or Smart Clothing. This can enable continuous monitoring of the patient's vital signs, even when they are on the move.

Mobile Applications: The system can be integrated with mobile applications, enables patients to monitor their health and share the data with their healthcare providers. This can allow remote monitoring of the patients and reduce the need for in-person visits.

Machine Learning Algorithms: Integrating machine learning algorithms into the system can enable the detection of abnormal heart rhythms and conditions such as arrhythmia or tachycardia. This can allow early detection of heart disease and other cardiovascular conditions.These future enhancements and advancements in wearable technology, mobile applications, machine learning algorithms can make the system even more effective in monitoring and managing the patient's health.

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