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Taisiya TRETIAKOVA[1]

Opiekun naukowy: Alexander MOLNAR[2], Vitaly GERASIMOV[3]

MOBILNY SYSTEM TELEMETRII MEDYCZNEJ

Streszczenie: Opracowaliśmy miniaturowy system telemetrii medycznej, który gromadzi informacje o parametrach fizycznych człowieka (tętno, poziom tlenu we krwi SpO2, ciśnienie tętnicze, elektrokardiogram, zmienność rytmu serca, częstość oddechów, temperaturę ciała, poziom cukru we krwi) oraz przesyła dane przez Bluetooth do smartfona i zapisane na dysku lokalnym w celu dalszego przetwarzania i zapisywania jak osobista czarna skrzynka (w samolocie). System oparty jest na platformie MAXREFDES100# Health Sensor Platform z dodatkowymi czujnikami, które upraszczają i przyspieszają rozwój. Oprogramowanie dla komputerów PC kompatybilnych z IBM i dla systemu Android pozwala konfigurować, gromadzić i przetwarzać „surowe" dane z czujników. Zmodyfikowaliśmy tę platformę, zmieniając wbudowane oprogramowanie, które pozwala zdefiniować dodatkowe parametry, takie jak ciśnienie krwi i częstość oddechów.

Słowa kluczowe: telemetria medyczna, bioczujniki, parametry człowieka

MOBILE MEDICAL TELEMETRY SYSTEM

Summary: We have developed miniature medical telemetry system which gathers information of physicals human's parameters (pulse rate, blood oxygen level SpO2, arterial pressure, electrocardiogram, heart rate variability, breathing rate, body temperature, blood sugar level) and data are transmitted by Bluetooth to a smartphone and saved in local drive for further processing and saving like personal black box (which on the plane). The system are based on MAXREFDES100# Health Sensor Platform with additional sensors which simplify and speeds up development. Software for IBM-compatible PC and for Android allows you to configure, accumulate and process "raw" data from sensors. We have modified this platform by changing the built-in software, which allows you to define additional parameters such as blood pressure and respiratory rate.

Keywords: medical telemetry, biosensors, human`s parameters

[1] Uzhhorod National University, Department of the Physics of Semiconductors, Biomedical Engineering: tretyakova.tajisiya@student.uzhnu.edu.ua
[2] Dr., Professor, Uzhhorod National University, Department of the Physics of Semiconductors: alexander.molnar@uzhnu.edu.ua
[3] Ph.D. Mukachevo State University, Faculty of Economics, Management and Engineering, vitgerv@gmail.com

1. Introduction

Today, we have a lot of varieties of systems and methods for monitoring biomedical parameters of human. All of them need improvement, but sometimes completely new equipment is created.
The development and improvement of these systems depend on the indicators that we need to obtain. Also, high accuracy of the investigated values is also very important.
Our purpose is a development of a miniature system for gathering biomedical parameters of person for the intention of complex patients diagnoses during the performance of his usual actions, including those physical exertion.
This system can be used to monitor the health of sportsmen, especially during the rehabilitation period.

2. System Description

We modernized system for researching biomedical parameters of human. System has glucometer added for researching stable sugar level. Also we can follow sportsmen muscles condition.
It is multisystem which can fixate several basic life parameters. These are: pulse rate, blood oxygen level SpO2, arterial pressure, electrocardiogram, heart rate variability, breathing rate, body temperature, blood sugar level.
Our system based on MAXREFDES100# Health Sensor Platform with additional sensors which simplifies and speeds up development. Software for IBM-compatible PC and for Android allows you to configure, accumulate and process "raw" data from sensors.

3. MAXREFDES100# health sensor platform

Maxim MAXREFDES100# health sensor platform is an integrated sensor platform that helps customers evaluate Maxim's complex and innovative medical and high-end fitness solutions. The platform integrates one biopotential analog front-end solution (MAX30003/MAX30004), one pulse oximeter and heart-rate sensor (MAX30101), two human body temperature sensors (MAX30205), one 3-axis accelerometer, one 3D accelerometer and 3D gyroscope, and one absolute barometric pressure sensor.
Modes of Operation

The Health Sensor Platform can be used in any of the three modes listed below.

- Tethered Mode: The user can connect the Health Sensor Platform to a PC-based GUI using a USB-C cable. This mode supports all sensors installed on the board including ECG, Optical, and Temperature sensors. The GUI provides options to run quick demos (with default register settings) and to evaluate any of the sensors in detail by changing the register settings of each individual sensor or analog front end.

- Untethered Mode (Offline): The Health Sensor Platform collects data and saves it to the onboard flash. The data can be downloaded later for post-processing. This mode requires the Health Sensor Platform to be connected to the PC GUI, as in Tethered Mode, to configure the sensors and write the mission to the onboard flash, which later can be disconnected and run untethered. To operate in this mode, the battery holder and the coin cell (not included in the box) must be installed.
- Untethered Mode (Real time): Customers can stream data in real time to an Android. We have provided a few functions to demonstrate how to connect the platform to the app. Customers can use the source code provided to develop the app to address their specific use cases. Here is the list of functions enabled in the app:

  - Temperature using Temp Sensors
  - Barometer Pressure using Pressure Sensor
  - HR using ECG Analog Front End
  - Position of the board using Accelerometer
  - The first two functions stream as soon as the HSP board is connected to the app. The last two functions need customers to set up a mission before connecting to the app.

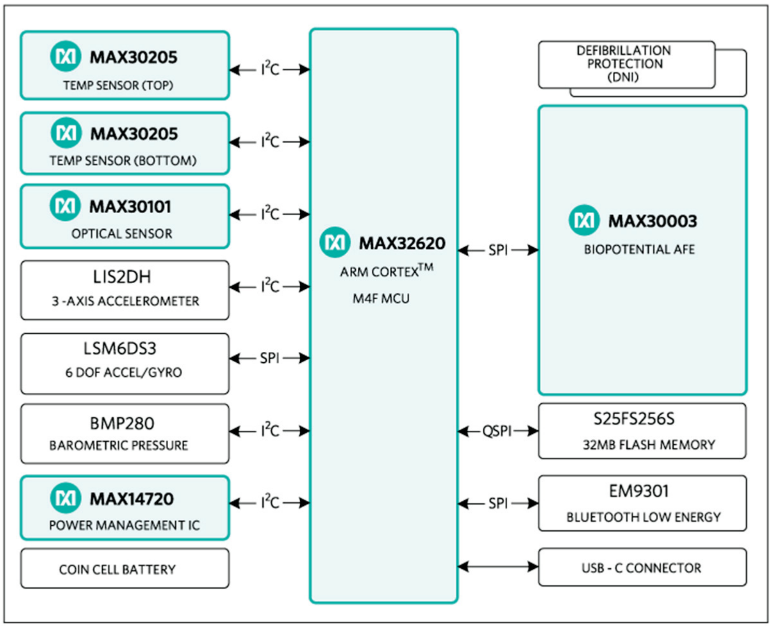

Figure 1. The MAXREFDES100# health sensor platform internal structure

PC and Android applications are provided on the Design Resources tab to help you get up and running quickly. The PC application provides a graphical user interface (GUI) allowing you to configure and interact with all the sensors over a USB connection. The Android application provides the ability to monitor sensor data over BLE. Instructions for installing and running the applications are found on the details tab.

The ARM mbed development environment is supported for developers who want to customize the operation of the platform. The companion MAXREFDES100HDK# programming adapter that ships with the platform provides driverless drag-and-drop programming for firmware updates as well as a virtual UART interface and CMSIS-DAP compatible debugger. For more details on firmware development and source code examples visit the MAX32620HSP platform page on the ARM mbed developer site [1].

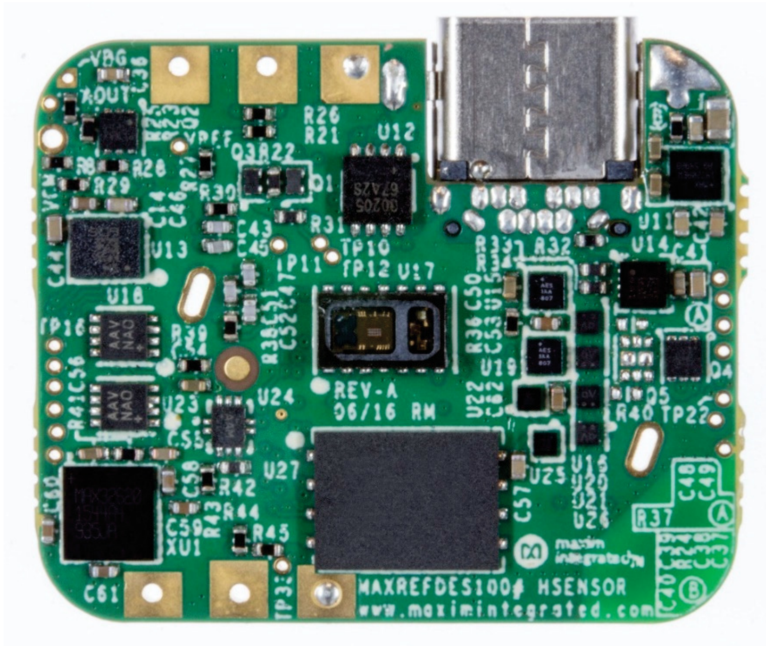

Figure 2. The MAXREFDES100# external view (approx. 3x2 cm^2).

3.1. Maxim Blood Pressure Trending System

Maxim Blood Pressure Trending (MaximBPT) is a BP measurement system using a photoplethysmography (PPG) signal obtained from the fingertip. The system requires user-specific calibrations, and successive measurements are relative to this calibration point. The goal of the system is to make BP measurements readily available to the user through widely available consumer devices like smartphones or wellness watches. The system is most useful and accurate when measurements are taken in a resting state, as in traditional cuff-based BP systems.[2]

3.2. SpO2 Subsystem

The SpO2 subsystem contains ambient light cancellation (ALC), a continuous-time sigma-delta ADC, and propri- etary discrete time filter. The ALC has an internal Track/ Hold circuit to cancel ambient light and increase the effec- tive dynamic range.

The SpO2 ADC has a programmable full-scale ranges from 2µA to 16µA. The ALC can cancel up to 200µA of ambient current. The internal ADC is a continuous time oversampling sigma-delta converter with 18-bit resolution. The ADC sampling rate is 10.24MHz. The ADC output data rate can be programmed from 50sps (samples per second) to 3200sps.

3.3. Temperature Sensor

The MAX30101 has an on-chip temperature sensor for calibrating the temperature dependence of the SpO2 subsystem.The temperature sensor has an inherent resolution 0.0625°C. The device output data is relatively insensitive to the wavelength of the IR LED, where the red LED's wave- length is critical to correct interpretation of the data. An SpO2 algorithm used with the MAX30101 output signal can compensate for the associated SpO2 error with ambient temperature changes.

3.4. LED Driver

The MAX30101 integrates red, green, and IR LED drivers to modulate LED pulses for SpO2 and HR measurements. The LED current can be programmed from 0 to 50mA with proper supply voltage. The LED pulse width can be programmed from 69µs to 411µs to allow the algorithm to optimize SpO2 and HR accuracy and power consumption based on use cases.[3]

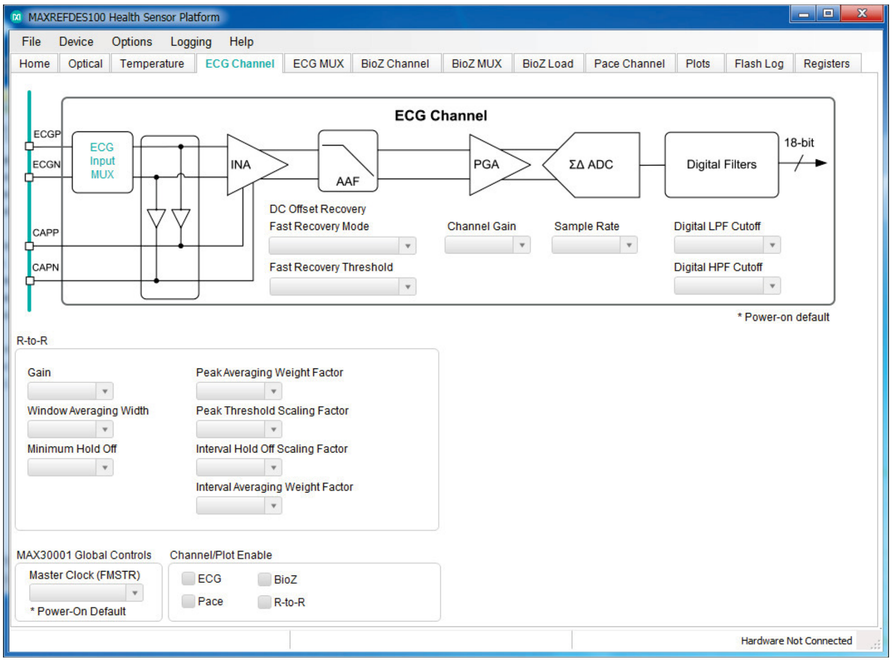

Figure 3. The MAXREFDES100# Health Sensor Platform v.3.02.

4. Control Software

The source codes of the software built into the controller are available on the website of the MAXIM company, which provides us with the possibility of modifying the firmware of the platform. The idea was that by processing the raw data of the cardiogram by low-frequency modulation of its amplitude, it is possible to determine the patient's respiratory rate, and based on the photoplethysmography data, we can determine the blood pressure. True, the last parameter is only approximate, and is not suitable for medical use (requires calibration for a specific person), however, this accuracy is quite enough to check the condition of athletes during training.

5. Conclusion

The use of the MAXREFDES100# reference design allowed us to quickly develop a human condition monitoring system that determines the main parameters of human life, such as pulse rate, cardiogram, blood oxygen level, body temperature, blood pressure, respiratory rate and body position in space (important when falling). The use of such systems at a relatively low cost allows you to monitor patients (older people, children, emergency workers, military, etc.) in real time. In addition, by equipping this platform with a relatively large amount of memory, it can be used as a personal analogue of the "aviation black box". Due to its ultra-low power consumption, this platform can be powered by an alternative ferroelectric-based energy harvester, which allows it to operate almost indefinitely [4].

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