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TELEMETRYCZNY SYSTEM DLA E-UBRAŃ (INTELIGENTNEJ ODZIEŻY)

Streszczenie: W artykule opisano budowę prototypu przenośnego urządzenia elektronicznego do zdalnego ustawiania podstawowych e-ubrań. Takie e-ubranie gdy jest noszone np. przez pracownika stanowi system "ubranie-człowiek". Urządzenie sterujące dla takiego systemu zbudowano używając technologii bezprzewodowych mikrokontrolerów. Mobilny system pomiarowy z zastosowaniem mikrokontrolera TI MSP430 jest opisany w pracy. Ten system śledzi zdalnie (monitoruje) parametry e-ubrania. Ubranie robocze pracownika szklarni zostało przeanalizowane jako przykładowy modelowany obiekt.

Słowa kluczowe: e-odzież, inteligentne ubrania, czujniki, mikrokontrolery, telemetria bezprzewodowa

TELEMETRY SYSTEM FOR SMART CLOTHES

Summary: In this article the construction of an experimental sample of a portable electronic device for fixing the basic parameters of the system "clothes-man" on the basis of modern wireless microcontroller technology has been suggested.The mobile measuring system based on TI MSP430 microcontrollers to track the parameters of "smart clothes" has been presented. The uniform of a worker for the greenhouse has been proposed as a modeling object.

Keywords:smart clothes, sensors, microcontrollers, wireless telemetry

1. Introduction

Today, there are many dangerous professions in our lives. The most dangerous are rescue workers, firefighters, steelworkers, military men and so on. One of the main means of protection from the dangerous environment is protective clothing and

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additional protective devices (e.g. balloons with compressed air, steel plates, and so on). All this leads to a complication of performing the task, but it is necessary for safe health or life. Significantly improved protection of special clothing is the usage of modern electronic systems [1].

The uniform of a worker for the greenhouse has been chosen as a sample. In fact, the incidence of temporary disability of workers in greenhouses is 5 times higher than that of their colleagues who work with similar chemicals on the open soil, and 10 times higher than in people who do not come into contact with pesticides and fertilizers.

The authors offer modern electronic controls of vital functions of the human body integrated in clothing (in under and above local area of a uniform) [2]. The essence of this proposal is that sensors of various types are mounted into the clothing which fix important indicators of internal and external surroundings, such as temperature, humidity, duration of stay, sensors of chemically hazardous substances, and so on (Fig.1). Modern developments in the field of microcontrollers' technologies allow processing the data with high speed and efficiency, besides, they are easily mounted into portable systems of various types. It is especially necessary to mention the widespread introduction of wireless admission-transmission systems that can significantly improve the efficiency of the so-called "smart clothes" [3]. Thus, in case of critical situations the microcontroller having analyzed the information from the sensors embedded in the worker's clothes by special means of signaling (warning sound or indicative ones, for example, will report on the danger of the worker's state to the controlling remote station, making the occurrence of a critical situation for the health or life of a man impossible) [4].

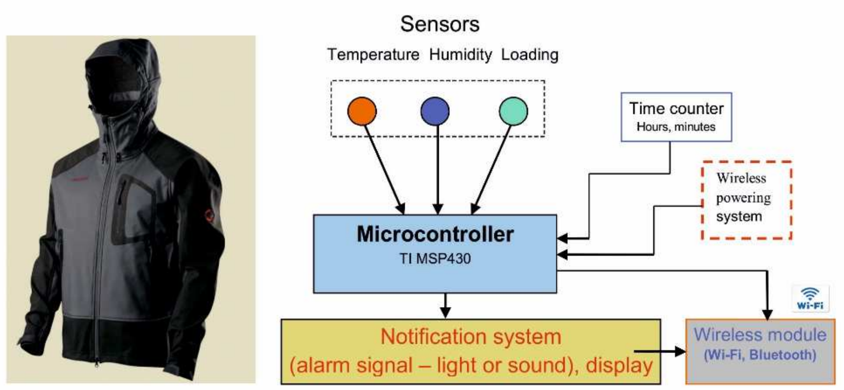

Figure 1. The intelligent uniform based on new digital technologies

2. Implementation

The portable monitoring system for "smart clothes" was designed to be fixed in clothes and worn comfortably. The system consists of the main module (device) and sensors, which are connected with the module through flexible wires.

The measuring system (Fig.2) consists of deformation sensors 1-4 (CP 0152 sensors - 4pcs), pressure (loading) sensors 5-8 and two combined temperature-humidity-pressure sensors 9,10. Because sensors 1-8-are resistive and strain - gauge ones, for their approval the bridge switching circuit is used. The sensors are divided into two groups and powered from digital-to-analog converters (DAC). This allows to adjust their sensitivity within a very wide range. The signal from each bridge reaches the amplifier with variable gain (PGA), and further to the input of the analog-to-digital converter (ADC). The digital code that is responsible for the amount of strain and pressure through digital insulators (TI ISO7341 and ISO7340) is supplied to the input of TI MSP430F5529LP [5] microcontroller, and after pre-processing by wireless technology to the host computer [6]. The use of digital isolators protects a man (on whom the sensors are fixed) from the accidental voltage contact. The level of protection is more than 5000V. In addition, the galvanic isolation provides a significant reduction in noise from the digital part of the measuring system. The reading speed of measurement results changes with the use of the control program and can be within the range of 0-100 measurements per second for one channel.

Two combined temperature-humidity-pressure sensors (Bosch BME280), one of which is under the clothes and the other - outside, allow measuring the microclimatic conditions under the object of study, and controlling the air microcirculation. I^2C interface was used to communicate with the main board for these sensors [7].
CC3100BP modules organize wireless communication of the measuring system. This module gives us a possibility to send data to any suitable receiver. With this module, we can build truly functional low-power wireless solution.CC3100BP and MSP430F5529LP microcontrollers are connected through SPI. The device is powered by TI BOOSTXL-BATPAKMKII.

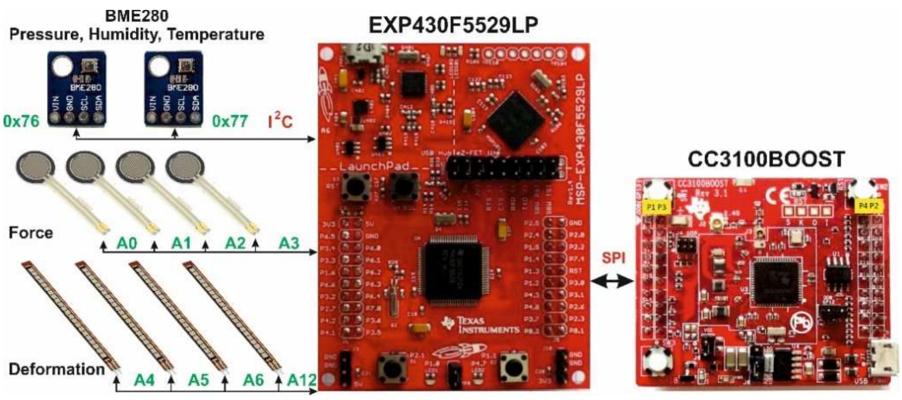

Figure 2. The example of the measuring system for "smart clothes"

3. Experimental data

The whole system operates correctly and the data can be received onto a smartphone, tablet or any Android - based device. The range of the designed system is very appropriate. In free space it is about 120 metres (in case of a short antenna) and more than 200 metres (with a long antenna). The signal easily passes through walls and the floor. The data request takes place every second and continues until the receiving device is connected. The results of transmitted data (pressure, temperature, humidity and strain) to the receiver are presented in Fig. 3 for *Access Point*mode.

4. Software

The main part of the measurement system control software was written in Energia MT v.0101E0017 [8]. For input data from Bosch BME 280 sensors, we used *cactus_io_BME280_I2C* library. Reading the data from analog inputs was realized through standard Energia*analogread* function. For communication with hardware (BME280 and CC3100BP) Energia*Wire* and *SPI* libraries were used. CC3100 was switched to Access Point mode, and Web server on port 80 began to operate. The monitoring data were transmitted to USB-Serial via virtual COM port for debugging.

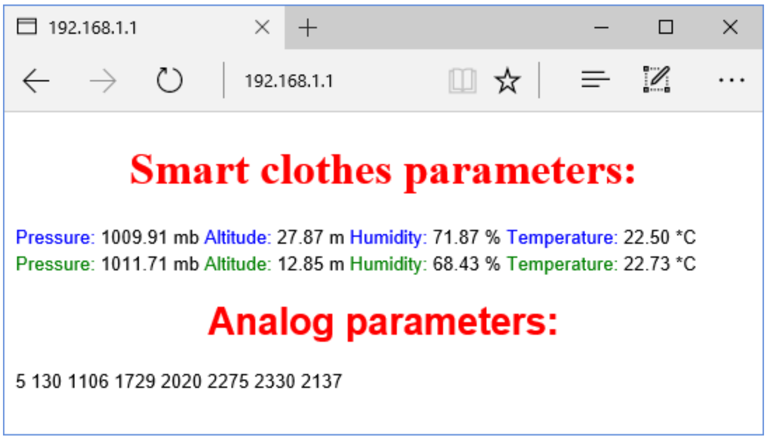

Figure 3. The data received from digital and analog sensors inWeb mode

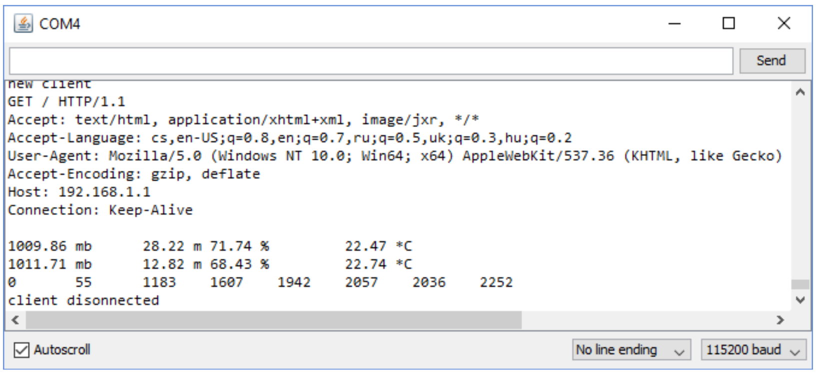

Figure 4. The example of the obtained data for debugging

On the whole, the system operates correctly. The main advantage of this realization is the usage of any type of clients (smartphone, tablet PC etc.) for monitoring. The disadvantage is low speed of data transfer, limited by the refreshing rate of web page (not critical for temperature, humidity and pressure). Unfortunately, without CC31XXEMUBOOST - Advanced Emulation BoosterPack for SimpleLink Wi-Fi CC3100 BoosterPack plug-in module, we don't have a possibility to upload data to the internal CC3100BP flash memory, and realize impressive graphic Web-design of our measurement system interface. We leave this feature for the future.
The sample part (initialization) of the control software is as follows:

```
#include <SPI.h>
#include <WiFi.h>
#include <Wire.h>
#include "cactus_io_BME280_I2C.h"

// Create BME280 object
BME280_I2C bme; // First BME280 sensor I2C using address 0x77
BME280_I2C bmf(0x76); // Second BME280 sensor I2C using
address 0x76

// Constants used to give names to the pins used:
const int analogInPin0 = A0; // Analog input pin A0
.
const int analogInPin12 = A12; // Analog input pin A12

int sensorValue0 = 0; // value read from the A0
.
int sensorValue12 = 0; // value read from the A12

const char ssid[] = "SmartClothes";
const char wifipw[] = "12345678";

WiFiServer server(80);
```

5. Conclusion and summary

Thank to Texas Instruments professional parts, tools, great documentation, reference designs and support community forum we were able to develop, build and test measurement systems in a short time.
Total cost of the designed device in case of manufacture is about 100 $ (without outfit). After integrating in clothes this device can be fully functional and could be used in any branches where a special type of the uniform is needed.
To increase the autonomy of the telemetry system it is advisable to use modern energy harvesting systems for converting movement, deformation and the heat of human body to electricity [9].

REFERENCES

1. RODRIGUESJ.P.C., DÍEZ I.T., ABAJO B.S.: Telemedicine and E-Health Services, Policies, and Applications: Advancements and Developments. IGI Global, 2012.
2. CHO G., RATON B.: Smart clothing – technology and applications. CRC Press, Taylor &Francis Group, 2010.
3. Smart Clothes and Wearable Technology. Woodhead Publishing, 2009.
4. MÄNTYJÄRVI J., HOISKO J., KAARIO J., KIMMEL J.: Patent: System and method for smart clothing and wearable electronic devices. US 6801140 B2, US20020084901, Nokia Corporation, 2004.
5. JIMÉNEZ M., PALOMERA R., COUVERTIER I.: Introduction to Embedded Systems: Using Microcontrollers and the MSP430. Springer, 2014.
6. KURITNIK I.P., MIKULSKI M., KARPINSKI W.: Bezprzewodowa siec sensorow. Pomiary Automatyka Robotika, **6**(2010)56, 548-551.
7. MOLNAR A., GERASIMOV V., KURYTNIK I.P.: The Development of Monitoring Devices in the „Man-Clothes" System Based on Modern Microcontrollers. Pomiary Automatyka Robotika, **2**(2016)20, 11-15.
8. Serwis internetowy: *http://energia.nu/,* 28.10.2016
9. MOLNAR A.A., KURITNIK I.P., GERASIMOV V.V., KARABEKOVA D.ZH.: Pezoelektrichestvo kak istochnik elektroenergii dlya portativnyih elektronnyih ustroystv v sisteme «chelovek–odezhda». Vestnik karagandinskogo universiteta, Seriya FIZIKA, N 4(2015)80, 62–65, (in russian).