

## MEASUREMENT OF ENVIRONMENTAL PARAMETERS USING WIRELESS SENSOR NETWORK TECHNOLOGY BASED ON NI MYRIO PLATFORM

Evgenia S. Bauer, Lyudmila V. Galsanova  
Scientific adviser – Lyudmila I. Khudonogova  
National Research Tomsk Polytechnic University  
obidos@yandex.ru

### Introduction

Today wireless data collection and monitoring systems have become a reality due to wireless sensor network (WSN) technology. WSN consists of a big amount of distributed in space devices called nodes, which contain a set of sensors, microcontroller, and a radio transceiver for communication over distances up to 100 m.

WSN is applied in a wide range of fields. Measurement of temperature, pressure, humidity and luminance level can be carried out by WSN both inside and outside a building. Thus, WSN is frequently used for conditions control in industrial premises. Moreover, WSN allows to collect measurement data from areas which are difficult or impossible to access due to harsh environment.

The purpose of this work is to develop a WSN application, obtaining and transmitting measured data from sensors by means of software for data collection.

### 1 Hardware

In this work, a role of WSN node was performed by an embedded hardware device National Instruments (NI) MyRIO. NI MyRIO is a reconfigurable and reusable tool for creating engineering applications for industrial control, robotics, and mechatronics. It features a dual-core programmable processor and a customizable Xilinx field programmable gate array (FPGA). The FPGA capabilities along with onboard memory and built-in Wi-Fi allow to deploy applications remotely and run them without a remote computer connection[1].

Environmental parameters measurement was carried out by 10 degrees of freedom inertial measurement unit (IMU) sensor. IMU-sensor contains accelerometer, gyroscope, compass, and barometer microcircuits. In this work, the barometer microcircuit LPS331AP was used. It determines atmospheric pressure and temperature[2].

The LPS331AP is an ultra-compact absolute piezoresistive pressure sensor. It includes a monolithic sensing element and an IC interface able to take the information from the sensing element and to provide a digital signal to the external world. The sensing element consists of a suspended membrane realized inside a single mono-silicon substrate[3]. Basic mechanical characteristics of the barometer microcircuit are reduced in Table 1.

Figure 1 shows WSN installation connection scheme. Obtained data from IMU-sensor are transferred to MyRIO via Inter-Integrated Circuit (I<sup>2</sup>C)

bus and then from MyRIO to central node via Wi-Fi. I<sup>2</sup>C is data serial bus for communication integrated circuits, which is commonly used to connect low-speed peripheral components with a motherboard, embedded systems and mobile phones.

Table 1 – Mechanical characteristics of the barometer microcircuit

| Parameter   | Value            |
|---|------------------|
| Operating temperature range, °C                   | from -40 to 85   |
| Full accuracy temperature range, °C               | from 0 to 80     |
| Absolute accuracy temperature, °C                 | ±2               |
| Operating pressure range, mbar                    | from 260 to 1260 |
| Relative accuracy over pressure, mbar             | ±0,1             |
| Absolute accuracy pressure over temperature, mbar | ±2               |
| Pressure output data, bits                        | 24               |
| Temperature output data, bits                     | 16               |

The data are transmitted via two communication lines – Serial data line (SDA) and Serial clock line (SCL). There are a master and a slave: master generates the clock pulse and slave receives the clock and responds when addressed by the master. A two-wire bus can have up to 127 devices what is significant for WSN application.

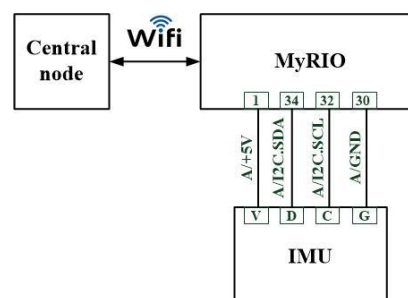


Figure 1 – WSN installation connection scheme

### 2 Register configuration

In order to read the data from sensor it is necessary to configure registers.

Register is a device used to store  $n$ -bit binary data, and performing transformation on them. The microcircuit comprises a set of registers which are used to control its operation and to obtain pressure and temperature data. Register Address is used to identify them and to read or write data via the serial interface.

For obtaining temperature and pressure data, one input and five output registers were used. Input

Register CTRL\_REG1 (control register) is composed of 8 bits, located at address 20h: as it is shown in Table 2.

Table 2 –Input register configuration

|    |      |      |      |         |      |          |     |
|----|------|------|------|---------|------|----------|-----|
| 7  | 6    | 5    | 4    | 3       | 2    | 1        | 0   |
| PD | ODR2 | ODR1 | ODR0 | DIFF_EN | DBDU | DELTA_EN | SIM |
| 0  | 1    | 0    | 1    | 0       | 0    | 0        | 0   |

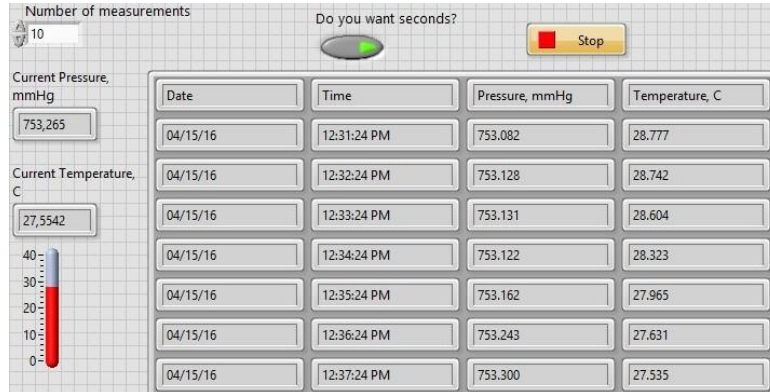


Figure 2 – Frontpanel

**PD** bit allows to turn on the device. The device is in power-down mode when PD = '0'. The device is active when PD is set to '1'. **ODR2- ODR1 - ODR0** bits allow to change the output data rates of pressure and temperature samples. The value is "101" which corresponds to output data rates 7 Hz for both pressure and temperature output. **DIFF\_EN** bit is used to enable the circuitry for computing of differential pressure output. If DIFF\_EN='0', the circuitry is turned off. **BDU** bit is used to inhibit the output registers update between the reading of upper and lower register parts. If BDU = '0', the lower and upper register parts are updated continuously. **SIM** bit selects the SPI serial interface mode. When SIM is '0' the 4-wire interface mode is selected [3].

Output registers are located at addresses from 28h to 2Ch. Registers of output pressure data are PRESS\_OUT\_XL (P<sub>XL</sub>), PRESS\_OUT\_L (P<sub>L</sub>), and PRESS\_OUT\_H (P<sub>H</sub>). To convert the obtained pressure values into appropriate units (mbar) it is necessary to use the formula (1).

$$P_{out}(\text{mbar}) = \frac{(P_H \cap P_L \cap P_{XL})_{dec}}{4096} \quad (1)$$

Next, let us consider the temperature data: TEMP\_OUT\_L (T<sub>L</sub>), TEMP\_OUT\_H (T<sub>H</sub>). Formula (2) is used to convert the temperature data into Celsius degrees.

$$T(^{\circ}\text{C}) = 42.5 + \frac{(T_H \cap T_L)_{dec}}{480} \quad (2)$$

### 3 Software

In this work, a program for collecting data from IMU-sensor using NI MyRIO was developed in graphical programming environment LabVIEW. The data are transmitted using the standard IEEE 802.11 (Wi-Fi) for wireless communication. The 802.11 standard defines two types of equipment: a

client, which is typically a computer, and an access point that serves as a bridge between wireless and wired networks.

Figure 2 shows front panel of program. User should specify only the number of measurements. Information about current pressure and temperature are shown on numeric indicators. The data are automatically measured once per minute and summarized in a table along with time and date.

Program operates by the following algorithm: firstly, the reference to I<sup>2</sup>C channel is opened; secondly, the transfer rate of I<sup>2</sup>C channel is configured; then, the data are written to I<sup>2</sup>C slave device and specified number of bytes is read until all the data are read off. Finally, the FPGA target is reset.

### Conclusion

In order to control environmental parameters and obtain relevant information about pressure and temperature, the program for collecting and transmitting data using NI MyRIO instrument and 10 degrees of freedom IMU-sensor was developed. The program allows to remotely measure pressure and temperature values and send measurement data to user computer via Wi-Fi. Due to WSN technology application, proposed measurement application gives an opportunity to cover large areas and monitor the parameters in regions which are difficult to access.

### References

1. NI myRIO [e-resource]: URL: <http://www.ni.com/myrio/> (дата обращения: 15.05.2016).
2. IMU-сенсор на 10 степеней свободы. [e-resource]: URL: <http://amperka.ru/product/troyka-imu-10-dof> (дата обращения: 15.05.2016).

3. LPS331AP. [e-resource]; URL:  
[https://www.pololu.com/file/download/LPS331AP.  
pdf?file\\_id=0J622](https://www.pololu.com/file/download/LPS331AP.pdf?file_id=0J622) (дата обращения: 21.05.2016).