WIRELESS SENSOR TRIGERRING USING BLUETOOTH LOW ENERGY TECHNOLOGY

David Veverka

Doctoral Degree Programme (1), FEEC BUT

E-mail: xvever05@stud.feec.vutbr.cz

Supervised by: Jiří Háze

E-mail: haze@feec.vutbr.cz

Abstract: This work deals with design of stable and fast wireless connection between two endpoints. The Bluetooth technology or its modern alternatives is used to realize this connection because this technology has already been tested in the desired environment. The results of timing analysis of the selected sensors are discussed as well as communication between sensor and a chosen microcontroller and in the end a complete solution will be designed in order to create a functional prototype of the desired application.

Keywords: Pressure sensor, Bluetooth technology, Wireless communication, Gazell, RFduino, Flow sensor

1. INTRODUCTION

The aim of this project is realization of fast and stable wireless connection between a gas flow sensor and a receiver. The use of low cost modules and Bluetooth Low Energy technology was one of the requirements. The technology was chosen thanks to its compatibility with the work conditions in which the modules will be further used. A development of concept based on timing measurements of tested modules and workplace characteristics was the main goal. Several variants of gas flow sensors were evaluated and in the end number of prototypes were realized including a casing for the sensor with mounting mechanism compatible with the desired machine. The prototypes were tested in the chosen work conditions where their functionality and utilization were tested and proved.

2. GAS FLOW SENSORS

There are many types of these sensors on the market. Various sensing mechanisms are used i.e. a turbine rotation detection, pressure difference or calorimetric principle.

As the best solution, a sensor using calorimetric principle was used mainly because of its dimensions and characteristics. There is a small heated element which is cooled by the flow of gas inside of the sensor. Thus the measure of cooling is equal to the increase or decrease of the flow of gas.

The chosen sensor FS7002 is manufactured by company Siargo Ltd. and has following parameters:

- gas flow detection from 0 m/s to 10 m/s,
- supply voltage 5 V,
- output voltage range from 0 to 3,3 V which corresponds to the full scale range,
- time delay 20 ms [1].

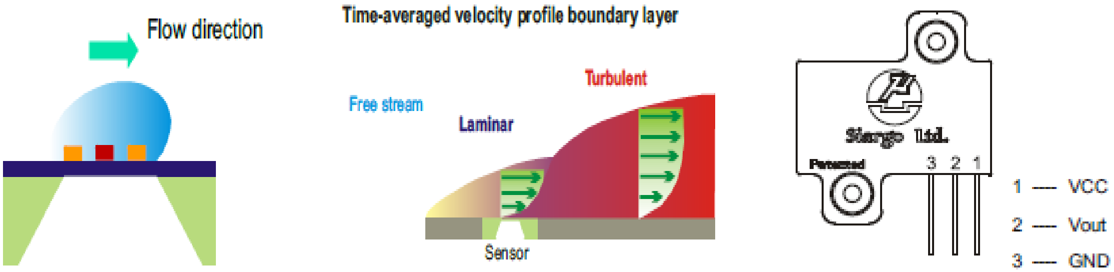

Figure 1: Sensor FS7002 and its functionality explanation [1]

A test unit mounted with a basic control circuit was realized to prove that the sensor housing is tight enough in order not to leak any gas from the valve. It was complicated to manage this tightness because of the characteristic of the used rare gas Argon but the leakage was reduced sufficiently to ensure reliable gas flow detection. The casing was made using a 3D printer and special resin. Figures 2 and 3 show the first and final prototype of the device.

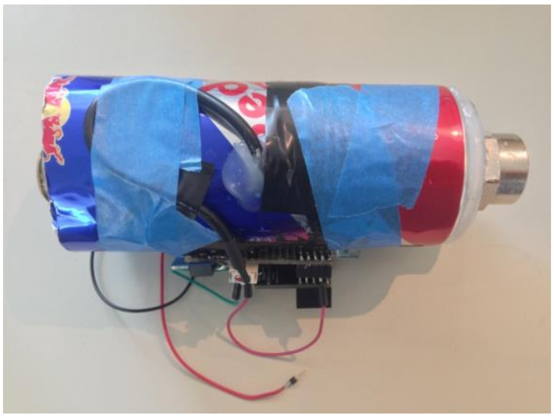

Figure 2: First prototype casing for FS7002 sensor with basic control electronics

The prototype on the figure 2 was further developed, the control electronics were redesigned and the casing was reduced in size. A small housing for the electronics was also designed. The final design can be seen in figure 3.

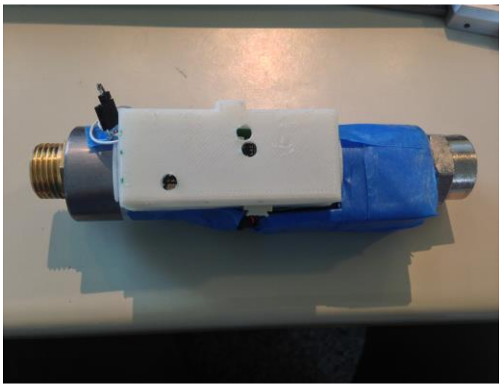

Figure 3: The final prototype of the sensor casing mounted with control electronics

3. COMPARISON AND OVERVIEW OF TESTED MODULES

Choosing of a proper microcontroller for the desired application was another important part. Main focus was placed on low power consumption, small footprint and sufficient amount of I/O ports. The stability of time delay during the streaming of data from sensor to the receiver was the most important parameter. Several modules from different manufacturers has been tested. Comparison of module parameters is shown in Table 1. In the table 2 there can be seen the result of time parameters testing with the final prototypes in the desired work conditions.

	Delay [ms]	Stability	Power consumption, Vs = 3.3V	Dimensions	Price per piece	Complexity
RFDuino	2 to 7	Very high	18 mA peak, 4 µA in LP mode	(L)15mm x (W)15mm	17$	Low
Bluno	8 to 10	Very high	18.6 mA	Chip only – 6x6 mm	8$	Low
RF Bee	7	Average	34.5 mA peak	(L)33mm x (W)24.4mm	16$	Low
XBee	9	Average	50 mA peak	(L)27.6mmx (W)22mm	23$	Low
BLE Mini	6 to 100	Very low	18.6 mA peak	(L)39mm x (W)18.5mm	30$	Avg.

Table 1: Overview of parameters of tested modules

Rf duino timing measurements	Delay between gas flow and light generation by the appliance
Min. delay: 10.9 ms Max. delay: 16.3 ms	Min. delay: 220 ms, Max. delay 250 ms

Table 2: Overview of timing parameters from final testing

3.1. CHOSEN MICROCONTROLLER

Based on the parameters in table 1 a microcontroller RFDuino was chosen thanks to its simple programmability, sufficient amount of I/O ports, dimensions and preprogrammed functions which allowed for very easy realization of the desired function.

Figure 4: Chosen microcontroller RFDuino [2]

The chip on figure 4 has following parameters:

- supply voltage 3,3V,
- bandwidth 2,4 GHz,
- CPU 16 MHz ARM Cortex-M0,
- dimensions 15mm x 15mm x 3,5mm,
- pin count 19,
- transmit power 4 dBm [2].

4. CONTROL ELECTRONICS

Several variants of electronics were realized which were used to test the proper functionality of the designed circuit. Only the last variant will be shown in this paper which was used in the final prototype.

4.1. CIRCUIT CONTROLLING OF THE SENSOR FUNCTION

Optimal functioning of the sensor and the microcontroller required utilization of voltage regulators in the circuit design. A charging circuit for the Lithium Polymer battery was also added as well as a header allowing programming of the microcontroller on the final PCB, several LED diodes for signalization and circuit for detection of the battery voltage level. The functionality of the sensor side is mainly based on processing the data from the attached flow sensor. The data is collected on the I/O port with an AD converter. When the value of the detected input voltage reaches the defined threshold it inverts the value in a global variable which is then sent over the bluetooth link to the receiver. The code also controls the battery level every half an hour and the signalization showing that the link is established and if the data are being transmitted over the link or not. The schematic can be seen in figure 5.

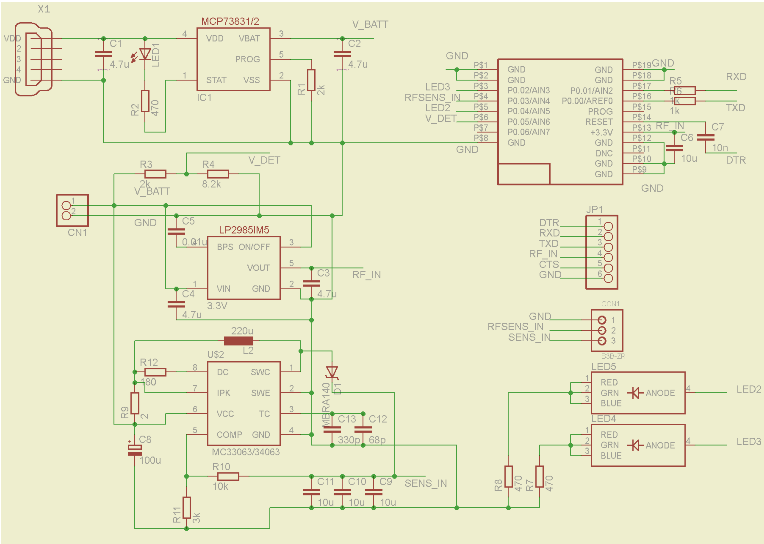

Figure 5: Schematic of control circuit for gas flow sensor

4.2. CIRCUIT CONTROLLING OF THE RECEIVER

The only difference between the previous circuit and this one is the omission of the sensor voltage regulator. One extra output port of the microcontroller was used for triggering the element which is connected to the receiver. The functionality includes the bluetooth connection establishment, pairing of the modules and simple data processing from the sensor which were used for deciding when to trigger the desired element. The battery level detection and LED signalization is the same as on the sensor side. The schematic is shown in the figure 6.

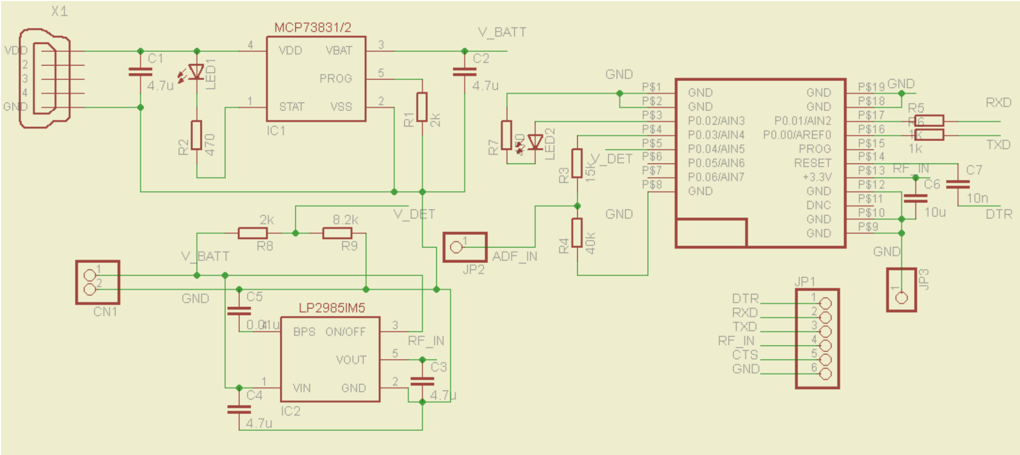

Figure 6: Schematic of the receiver

5. CONCLUSION

This work dealt with the design of a system for transmitting data from gas flow sensor to the receiver. The basic element was a gas flow sensor which measuring mechanism was based on the calorimetric principle. The solution was chosen mainly because of its dimensions because no other suitable sensor with sufficiently small footprint is fabricated. Further a casing for the sensor was designed and realized using 3D printing and special resin encasing. As the last part the control electronics for the sensor and the receiver along with PCBs were designed based upon the requirements of the final application. The final prototype was tested in the desired work conditions. The testing proved the functionality of the whole concept thanks to sufficient time frame for triggering the desired appliance. Thanks to this the concept is currently further developed.

REFERENCES

[1] Apollo Electronics. *www.apollounion.com* [online]. 2004-2013 [cit. 2014-05-01]. Available at: http://www.apollounion.com/en/down.asp?filename=Upload/DownFiles/FS7002-VB0.pdf

[2] RFduino: Rapid Development & Prototyping. *www.rfduino.com* [online]. 2013-2014 [cit. 2014-05-01]. Available at: http://www.rfduino.com/product/rfd22301-rfduino-ble-s