

**Petr WOJCIASZYK\***

ZIGBEE WIRELESS NETWORKS AND SMART SENSORS

BEZDRÁTOVÉ SÍTĚ ZIGBEE A INTELIGENTNÍ SENZORY

### **Abstract**

At the technological data acquisition and their backward distribution to production process is important to use intelligent sensor and actuator systems, which communicate with the control unit by network bus. Presently is very expressive trend using wireless technology for the network communication.

Extensive standard is Bluetooth. However Bluetooth isn't only standard from this category. One of the perspective category is wireless standard ZigBee, which communicates in license-free band with frequencies 868 MHz/915 MHz/2,4 GHz.

The board 13192DSK with ZigBee circuit is used on laboratory task - PC and ZigBee module, which includes 8-bit microcontroller MC9S08GT60 and acceleration sensors. MCU can cooperate with smart sensors for 1-Wire Net too and can be used in home automation (i.e. hot-air aggregate - physical model of air-conditioning).

### **Abstrakt**

Při sběru dat a jejich zpětné distribuci do výrobního procesu je důležité používat inteligentní senzorové a aktuátorové systémy, které komunikují s řídicí jednotkou po síťové sběrnici. Současným trendem je využívání bezdrátových technologií.

Rozšířeným standardem je Bluetooth. Avšak Bluetooth není jediným standardem v této oblasti. Jedním z perspektivních je standard ZigBee, který používá bezlicenční pásmo s frekvencemi 868 MHz/915 MHz/2,4 GHz.

Deska 13192DSK s obvodem pro ZigBee je použita v laboratorní úloze - PC a ZigBee modul, který má 8-bitový mikrokontrolér MC9S08GT60 a senzory zrychlení. MCU může také spolupracovat např. s chytrými senzory pro síť 1-Wire a být použit v domovní automatizaci (např. teplovzdušný agregát – fyzikální model klimatizace).

## **1 WIRELESS NETWORKS**

For data transmission in wireless nets is need to specify radio frequencies. These frequencies are threshold resources and they are under licence fee. Therefore are there license-free bands with frequencies worldwide 2,4 GHz, 5 GHz/915 MHz in America, 868/433,92 MHz in Europe. They are called Industrial, Scientific and Medical frequencies.

### **1.1 Comparing of wireless standards**

There are some wireless standards. They are mostly under control of Institute of Electrical and Electronics Engineers. Very popular are Wi-Fi (standard 802.11b/g – Wireless Local Area Network)

---

\* Ing., Department of Control Systems and Instrumentation, Faculty of Mechanical Engineering, VSB-Technical University of Ostrava, 17. listopadu 15, Ostrava, tel. (+420) 59 732 3511, e-mail: petr.wojciaszyk@vsb.cz

and Bluetooth (802.15.1 – Wireless Personal Area Network). One of perspective category is ZigBee (802.15.4). Comparing of their basic properties is in table 1.

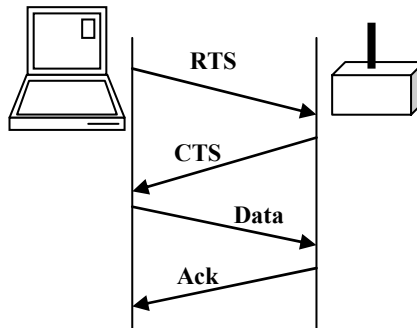
**Tab. 1** Basic networks’ properties

| Standard            | ZigBee               | Bluetooth | Wi-Fi      |
|---------------------|----------------------|-----------|------------|
| Transfer rate       | 20/40/250 kb/s       | 1 Mb/s    | 11/54 Mb/s |
| Range (m)           | 1-75+                | 1-100     | 1-100+     |
| Frequency           | 868/915 MHz; 2,4 GHz | 2,4 GHz   | 2,4/5 GHz  |
| Elements            | 255/65K+             | 7         | 30         |
| Battery life (days) | 10-1000              | 1-7       | 0,1-5      |
| System resources    | 4-32 KB              | 250 KB+   | 1 MB+      |

### 1.2 ZigBee networks

ZigBee utilizes the ISM communication band. It uses Direct Sequence Spread Spektrum method with 27 channels to communicate with other ZigBee devices. One channel is used at frequency of 868 MHz in Europe and with the transfer rate 20 kb/s. In America ZigBee uses at the frequency of 915 MHz 10 channels with the transfer rate 40 kb/s (band gap is 2 MHz). Worldwide frequency 2,4 GHz is used for 16 channels with the transfer rate 250 kb/s (with 5 MHz band gap).

Used access method is CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance). The device (node) checks to be sure the channel is clear (no other node is transmitting at the time). If the channel is not clear, the node waits for a randomly chosen period of time, and then checks again to see if the channel is clear. If the channel is clear, then the Request-to-send packet is sent. Second node (receiver) then sends Clear-to-send packet. The transceiver reply with data packed and waits for acknowledgement packet. Other devices (after receiver’s CTS packet) wait a time period. Method diagram is in figure 1.



**Fig. 1** CSMA/CA access method

The standard defines several topology types: peer-to-peer, star, cluster tree and mesh. In accordance with a network structure were different types of devices developed. There are Reduced Functionality Devices (only as the end node – with sensors or actuators) and Full Functionality Devices (network routers and coordinators, network interfaces).

Security of ZigBee network is provided by Advanced Encryption Standard. Access control and others can be used too.

## 2 ZIGBEE TASK

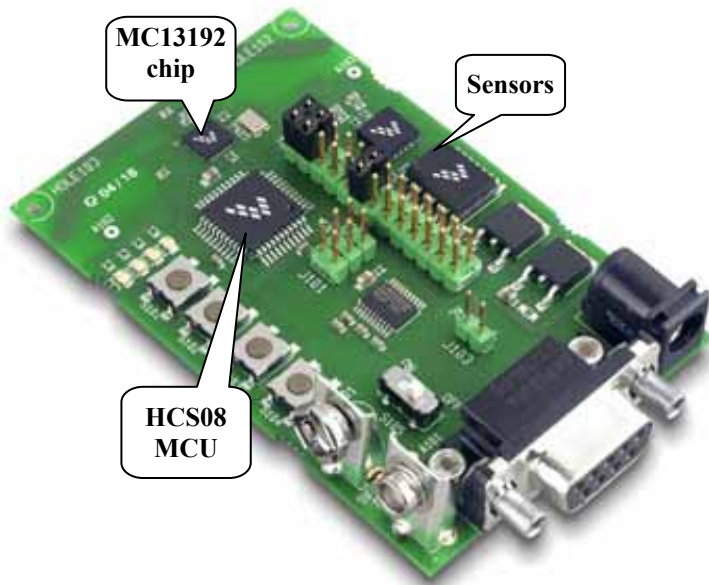
There is ZigBee demo task with parts from Freescale. Basic MCU (micro control unit) is MC9S08GT60, low-power, low-voltage HCS08 MCU (figure. 2) with 60KB of on-chip flash. Inner system reduces using of external circuits to minimum. The MCU includes timers, A/D converter, SPI, SCI, IIC interfaces, up to 36 inputs/outputs.



**Fig. 2** HCS08 MCU (MC9S08GT60)

### 2.1 ZigBee node

ZigBee task consists of two nodes and interface to communicate with PC (figure. 6). The node is board with MCU, ZigBee communication chip MC13192, sensors, switches, LEDs and support circuits (figure. 3 and figure 4).



**Fig. 3** Freescale 13192 DSK board

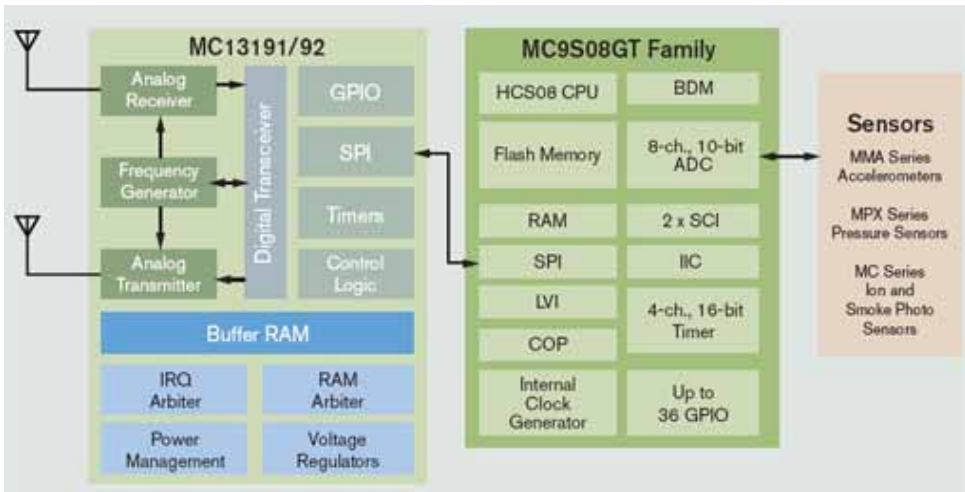


Fig. 4 13192 DSK board block scheme [Freescale 2004]

## 2.2 ZigBee task

The MCU senses sensor's voltage on the A/D converter. Captured data are sent through the SPI interface to the ZigBee chip. This chip provides wireless connection and the communication with the second node (block diagram on figure 5).

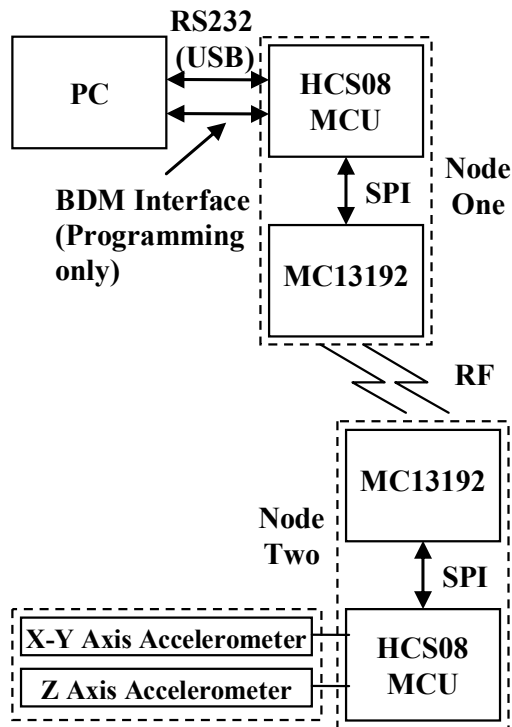


Fig. 5 ZigBee demo task block diagram

The second node transfers data to PC over the RS232 interface (or RS232 to USB converter too).

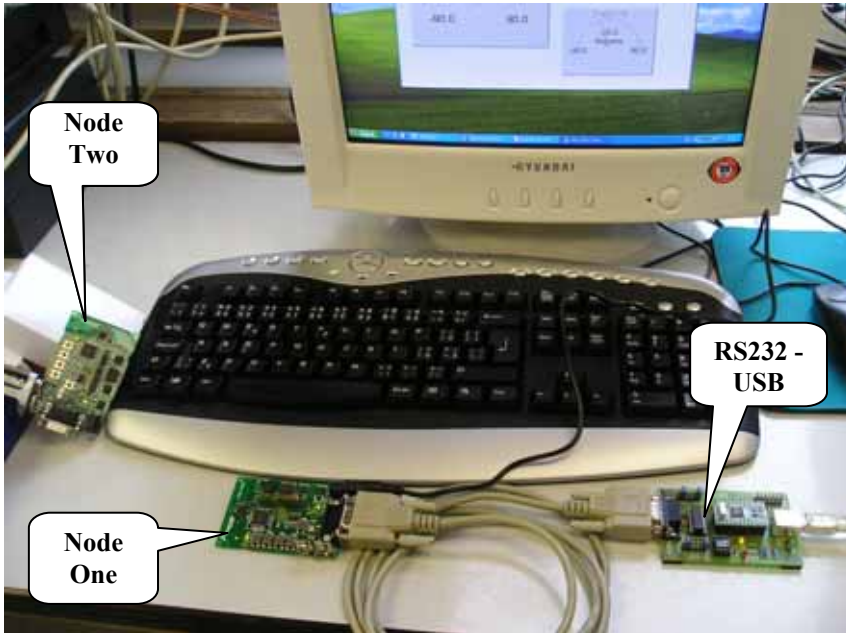


Fig. 6 Photo of the ZigBee demo task

### 3 CONCLUSIONS

The advantages of ZigBee are low-power consumption, high number of nodes and fast activation from standby mode. Purposed destinations are industrial and home automation (old buildings with cable pass impossibility) with many sensors (e.g. sensors for SCI, I2C, CAN or 1-Wire). This can be used for example in air-conditioning. The scheme of physical model (i.e. hot-air aggregate) with hot air source, venting and sensors is on figure 7 and 8.

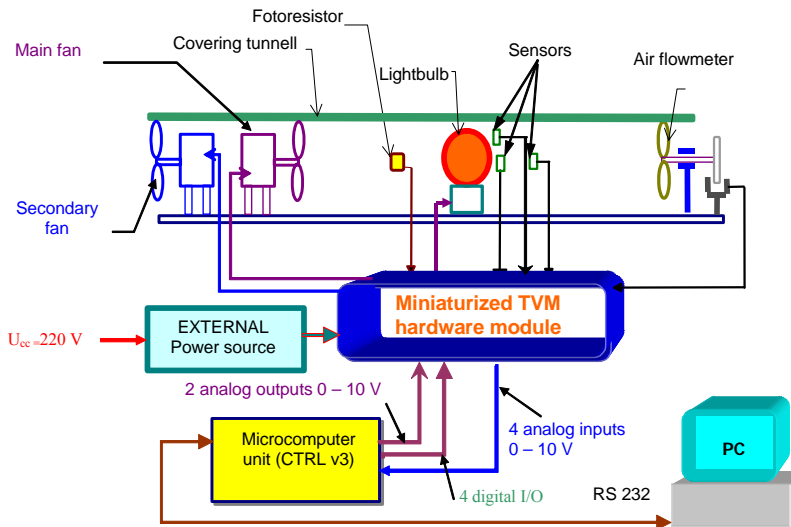
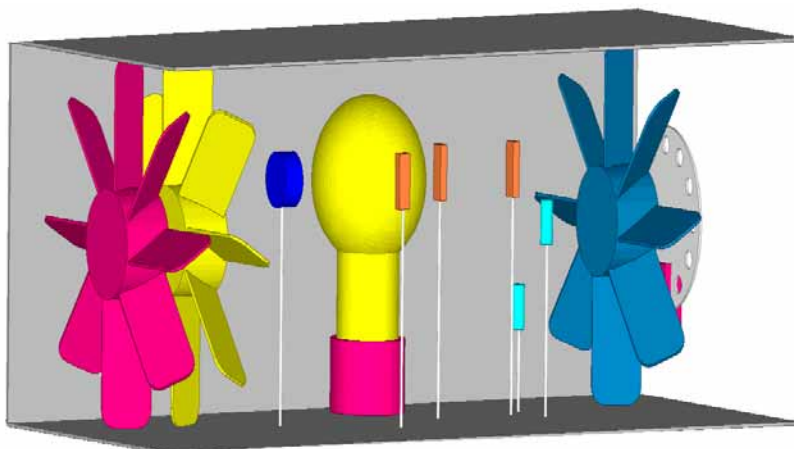


Fig. 7 Block scheme of experimental model HAA (Hot-Air Aggregate) [Smutný 2005]



**Fig. 8** 3D model scheme of experimental model HAA [Smutný 2005]

The problem is solved in the framework of the grant project Czech Science Foundation GAČR 101/04/1530.

#### REFERENCES

- [1] FREESCALE. *ZigBee Technology from Freescale*. [online] , 2004. Available from [www: http://www.freescale.com/files/wireless\\_comm/doc/brochure/brzigbeetech.pdf](http://www.freescale.com/files/wireless_comm/doc/brochure/brzigbeetech.pdf).
- [2] SMUTNÝ, L. *Teplovzdušný model TVM (klimatizační jednotka)*. Ostrava : VŠB-TU Ostrava, 2005, 46 pp. Project GAČR 102/03/0628.
- [3] ZANDL, P. *Bezdrátové sítě WiFi – Praktický průvodce*. Brno: Computer Press, 2003, 190 pp. ISBN 80-7226-632-2.
- [4] ZIGBEE ALLIANCE. *Zigbee Overview*. [online] , 2004. Available from [www: http://www.zigbee.org/](http://www.zigbee.org/).

**Reviewer:** prof. Dr. RNDr. Lubomír Smutný, VŠB-Technical University of Ostrava