Multisensor Network for Distance Data Pick-up

Husak,M. - Jakovenko,J. – Vitek,T.

Department of Microelectronics
Faculty of Electrical Engineering, Czech Technical University in Prague
Technicka 2, CZ – 166 27 Prague 6, CZECH REPUBLIC
husak@feld.cvut.cz

ABSTRACT

In the article there is presented a new concept of a multisensor network for distance wireless data pick-up and ones transfer via internet. Wireless sensor units are used for measure and data transfer to control unit. Wireless sensor unit is created by the sensor and wireless communication RF chip. The control unit is created by the wireless communication RF chip and serial connection to PC. The PC communicates with internet. The wireless communication RF chip can be used for bidirectional communication. The control software of the whole system has been designed. There are many program functions implemented. The design has been were verified by the realized system sample. All implemented functions can be displayed on WEB pages. Common software equipment can be used to view the web pages (PDA or mobile phone).

Keywords: Wireless, sensor, internet, measurement, data transfer

1 INTRODUCTION

Wireless transmission is very popular today for sensor data transmission. Commercially available RF modules or chips are available for this purpose. Most RF chips are capable to perform coding, decoding and transmitted data synchronization at least partly, they can also feature enhanced data security by adding CRC, parity bits etc. These circuits perform these activities without the need of programmed control, simplifying the programmer's work considerably. The RF chips are frequently fabricated in the form of transceivers (a transmitter and a receiver in a single package). The same chip can be used in all instruments, bidirectional communication presents no problems. Many producers also combine transceivers with other circuits like A/D converters or complete microprocessors.

The ZigBee communication system fits well to sensor data transmission. The standard makes possible mutual communication of numerous instruments over a distance of hundreds of meters. It is distinguished by low requirements on hardware and by extremely low power consumption. It is described by the IEEE 802.15.4 specification. ZigBee replaces the data transmission by RS232 or RS485 series bus.

In our case we have used a RF chip in the Nordic technology. Its principle of operation is similar to ZigBee. The chips operate at frequencies 433 MHz, 868 MHz, 915 MHz or 2.4 GHz. Transmission speed is 50 $kb \cdot s^{-1}$ and 250 $kb \cdot s^{-1}$ in the 2.4 GHz band. In the 868 MHz band, Nordic has 7 channels, as compared with 1 channel in ZigBee, 83 channels in the 2.4 GHz band compared to 16. The data frame is smaller, too, in addition to data it only contains a 10-bit header, 32-bit address and a 16-bit CRC. All chips are capable of bidirectional operation. The Nordic technology is simpler than ZigBee. It places lower requirements on the system sources, i.e. microprocessor and memory.

The paper describes design and implementation of a system solving transfer of measured sensor data via the Internet. A web page has been created on an Internet server where information is stored, processed, and displayed. The system is divided into four basic function blocs and each block can be used at a different location.

2 CONFIGURATION OF THE MULTISENSOR NETWORK

Measuring equipment acquires the data from the sensors. The device consists from the hardware and software for handling the sensors and sending the measured data to the computer.

Program for reading is determined for reading the data and saving them into the computer. The program sets up the measuring equipment for correct addressing the data from the sensors, i.e. where to store the data from which sensor. The configuration of the measuring equipment determines the number of the active sensors, the position of the inputs and other properties. Successive distribution of the measured data is realized using the Internet connection.

Data transfer software cooperates with the presentation layer. The software can run on the Linux as well as on the MS Windows platforms.

Presentation layer. This part is used for generating dynamic web pages. The web pages combine the text information and the graphical curves which are representing the measured data or some previously recorded data. The presentation layer consists of the set of the PHP scripts. The scripts are changing the server configuration, specifying the way of the data presentation, loading the data from the

database, changing the data, statistics from the measured data, creating the graphical characteristics, etc.

Web pages are generated by the web server and MySQL database server. These applications can be run on the several kinds of the operating systems. All software is running on the one computer, which is connected with the sensors. The system configuration for measuring the data at different locations is illustrated in Figure 1. Each measuring point can differ in the hardware and software equipment. This difference is caused by different demands laid on the measuring function of each part of the system.

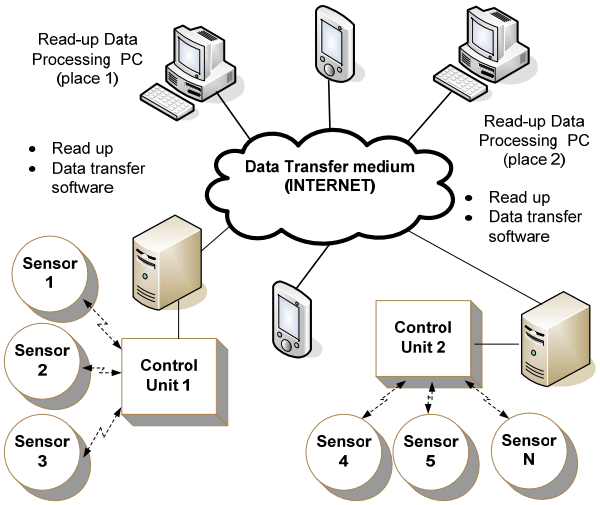

Figure 1: System measuring at different locations.

2.1 Concept of the sensor data pick-up

The Control Unit takes care of communication with wireless sensor units as well as access to the Internet environment – figure 2.

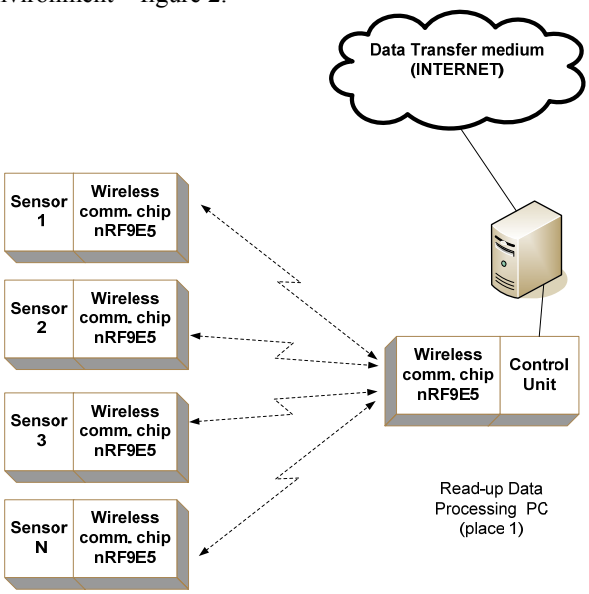

Figure 2: Principle wireless sensor data pick-up.

The system also includes a network of wireless sensor units. This network can have different topologies, i.e. either a direct communication with the control unit, or other network configurations. The wireless communication between the control unit and sensors is bidirectional, with a simplified CSMA (Carrier Sense Multiple Access) without collision detection.

Wireless Sensor Unit. Every sensor unit consists of the nRF9E wireless chip, program memory and a symmetrical output element – figure 3.

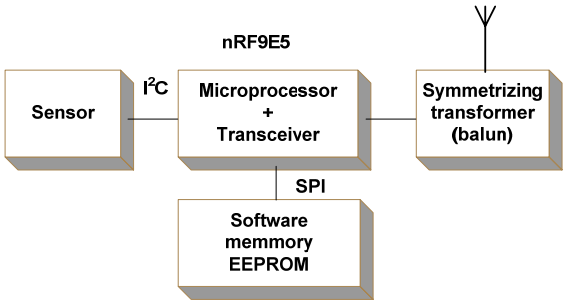

Figure 3: Wireless sensor unit.

The input block is the temperature sensor. The sensor used contains an A/D converter and a series interface. The communication with the microprocessor takes place over an I^2C bus. The second block is the microprocessor with integrated transceiver, processing the sensor data and communicating with the control unit. The program 25320 EEPROM memory serves to store the microprocessor program. The memory is connected through the SPI series bus. The external antenna is connected through a symmetrizing transformer (balun).

Control Unit. The block diagram of the control unit is shown in figure 4. Its circuit connection is very similar to the wireless sensor connection shown in Figure 3. The RS-232 interface is used for PC connection, because RS-232 implementation is very simple (having preference over USB). The interface is connected to UART of the processor. The converter MAX232 is used for change of logical levels.

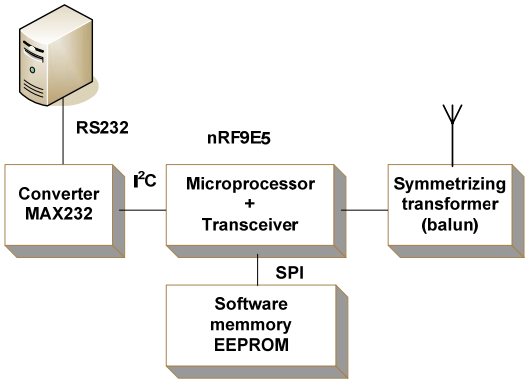

Figure 4: Control unit.

An ATMEL 89S8253 type was selected as the control processor. It is a 8051 architecture compatible microprocessor, containing additional 2 kB data EEPROM, 12 kB FLASH program memory, SPI interface and further hardware. Both the program and data memories are In System Programmable (ISP), by series programming through the included SPI interface. Further the circuit contains a 256 byte ARM memory, whose upper 128 bits are accessible by indirect addressing since they are shared with SFR special function register addresses. The lower 32 bytes of RAM are four register banks The instructions are fully compatible with the 8051 architecture and operate identically [2].

Wireless RF chip. The type nRF9E5 circuit was selected for the communication circuits design. The circuit contains a RF transceiver, an 8051 architecture compatible microprocessor and an AD converter [1]. It operates in the 433/868/915 MHz ISM bands with adjustable frequency and output power. GFSK (Gaussian Frequency Shift Keying) modulation is used for the transmission, featuring a lower bandwidth than conventional frequency modulation. The modulation width is ±50 kHz. The data are internally coded/decoded according to Manchester code, resulting in 50 kb·s^{-1} effective transmission speed. The transceiver communicates with the built-in microprocessor through an internal SPI interface. The AD converter in this circuit has 4 inputs and 10 bits resolution (up to 12 bits at lower frequencies and further filtration). The inputs can be operated as differential and the supply voltage can be measured internally. Resolution can be adjusted in 4 steps from 6 to 12 bits. The internal SPI interface is used for A/D converter control just like the transceiver. The circuit also has an input for AD converter reference voltage. Conversion time is 8 to 14 μs, depending on resolution. As further hardware the circuit contains a single-channel PWM modulator, controlled by PWMCON and PWMDUTY registers with 8 bit resolution. Further the Watchdog. The microprocessor is 8051 architecture-compatible. It includes 4 kB program memory, 256 bytes of data memory and special function registers. The upper 128 bits are accessible by indirect addressing since they are shared with special function register addresses. The program memory is a RAM type and the program is recorded in it by the Bootloader after SPI from the EEPROM memory after resetting. A header must be present in front of the program in the memory, containing the memory speed, crystal frequency and user data.

2.2 Used sensors in work

The DS620 sensor can be used for the measurement of temperature. The circuit contains a temperature sensor, A/D converter, comparator and a series interface [3]. The temperature measurement range is -55 ^{0}C to +125 ^{0}C. The A/D converter resolution can be adjusted from 10 to 13 bits. A twin-lead I^{2}C bus is used for communication. The circuit also contains an EEPROM memory to which a part of registers can be copied and so preserve the setting even when the power supply is disconnected.

The SHT11T integrated sensor can be used for the measurement of humidity or temperature. The output signal is in digital form.

The MPX4115A sensor is used for pressure measurement. A circuit is integrated one-chip Si sensor of absolute pressure. The sensitivity in the pressure range is 46 mV·kPa^{-1}. The pressure resolution is 0.045 kPa.

3 DATA READING AND TRANSFER SOFTWARE

The control program is divided to different functions. Individual functions control behaviour of the corresponding instrumentation parts. The wireless sensor unit control program is based on an endless loop, repeatedly performing the required operations, value measurement by the sensor, communication with the control unit, and low power consumption waiting mode. The operation sequence is shown in figure 5. The wireless communication of the control unit with the sensor units is performed by a program whose operational sequence is shown in figure 6. The program composition as well as program initialization are similar in both programs.

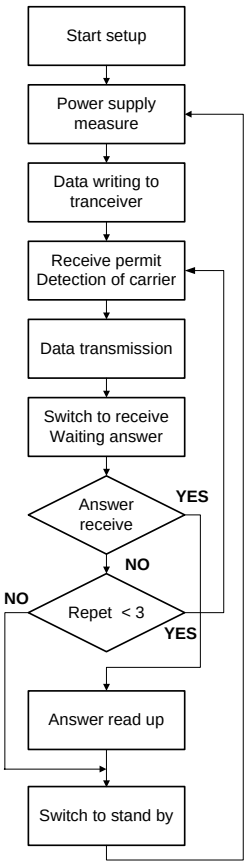

Figure 5: Flow diagram of wireless sensor unit.

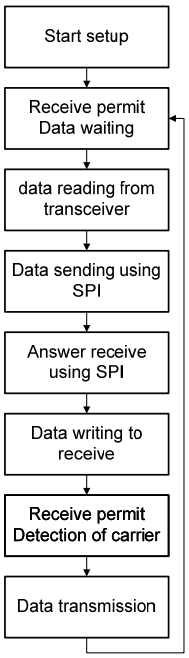

Figure 6: Flow diagram of control unit.

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Software for Support of Data Transfer via Internet performs data saving to a database. The data are acquired from the measuring device. The transfer and saving of data is realized using a PHP script. Another extension is represented by CURL that provides comfortable access to data via internet.

The database structure is very simple. Data series corresponds to the measured sensor value with assigned time value (the first column contains value of time, the second column contains measured value). The measured data are changing very slowly. The data are saved to the database only in the case of change (the result is acceleration of data operation). Therefore additional column is inserted to the structure. The duration of a certain value is saved in this column. The format „Unix Timestamp" is used for saving time information. Time values are represented by 32-bit number. PHP script converts that format. Other two matrices have been designed (they save time and space for data processing). The matrices contain partially preprocessed data, namely average values, minima, and maxima. The matrices serve for using data from a longer time interval.

Data saving. Data are read from data series in the files. Data are transformed to correct format and saved to the database. Data are not saved as a single series. One single SQL query is created. All new data are saved in batch mode. Operation speed is higher in that case.

4 WEB PAGES AND RESULTS

The basic requirements have been defined for the design of the web pages: Simple layout and well-arranged design, text display of current measure values, current measured characteristics within day, measured characteristics and text outputs for arbitrary data interval. The example of one page layout is shown in Figure 7.

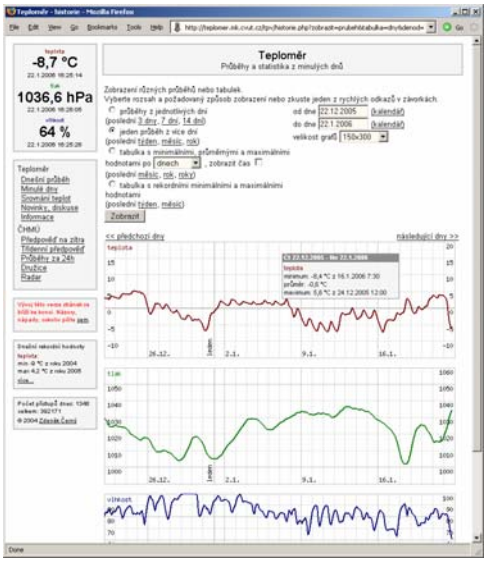

Figure 7: Web page layout

The main file controls a skeleton of the page. Page "history" allows to visualize the information in different way. Another file performs generation of all pictures.

5 CONCLUSIONS

The submitted paper shows a concept of solution of a wireless multi-sensor system for measurement and transmission of sensor data. The input side is a network of sensors, connected by wireless links with the control unit. The control unit communicates with a PC server connected to the Internet. The sensor network topology can be modified according to the particular needs of data-collecting sensor placement. The wireless sensor network can be utilized for measurement and data collection from various kinds of sensors. Nordic-type wireless technology is used for data transmission, featuring a range up to about 100 m. A chip of the technology mentioned is used for the high frequency transmission and reception section. This technology is distinguished by extremely small power consumption, enabling the system to be used for long-term measurements and data collection. The system can also be supplemented by wireless communication between the control unit and the Internet connected PC server. Right now the efforts are targeted at the wireless interconnection of the sensor network, as well as at wireless connection of the control unit to Internet. Control software of the whole system has been designed. Many program functions constitute the whole software. Individual functions perform individual operations of the system. The design has been verified by a realized system sample. All functions can be displayed on the web pages. Common software equipment can be used for viewing the web pages (PDA or mobile phone). Hardware and software of measuring device have been realized.

6 ACKNOWLEDGEMENT

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