WIRELESS TRANSMISSION OF BREATH RHYTHM IN TEXTRONIC SYSTEM

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Abstract
The textronic system includes textiles joined with electronic and computer technologies. The textronic clothing can be applied mostly for emergency forces (e.g firemen, rescue team of collier, mountain rescuers) and victims of disaster. Information from sensors placed in clothing is useful for rescuer and mostly for monitoring station that takes a decision while situations of threat to human life. It is obvious that wireless connection is only one solution of communication between textronic jacket of rescuer and monitoring station. Article describes vest with textile breath sensor. This vest can be part of textronic garment. The breath sensor uses electroconductive yarn. Information from described sensors was transmitted outside vest by radio link. Analysis of number of breath rhythm in different conditions was carried out. Transmitted and received data was compared.
Key words: breath rhythm, electroconductive yarn, wireless transmission, microcontrollers

Introduction

The textronic system includes textiles joined with electronic and computer technologies [1]. The textronic clothing can be applied mostly for emergency forces (e.g firemen, rescue team of collier, mountain rescuers) and victims of disaster. This kind of clothing includes electronic or textile sensors that measure physiological and ambient parameters, for example humidity and external temperature etc. Information from sensors is useful for rescuer and monitoring station. Data from sensors implemented in clothing structures can be sent to the monitoring station only by radio link [4].
Very important problem in breathing frequency measurement is knowledge of human's physiology. During respiratory cycle, the volume of chest is changing. This is the result of growing larger three dimensions: anteroposterior, transverse and perpendicular. The prototype of textile sensor was based on electroconductive yarns. The textile sensor had a form of knitted fabric structure and it contained an electrical input build in. This kind of a sensor is knitted to a 'normal' cotton material. The knitted fabrics contained electro-conductive Xsilver yarns. Silver (20%) was covering the polyester yarn as conductive material. Sensitive part of the material had dimensions of 90 x 30 mm and it was a 4-weave yarn. During the chest moving the sensor's resistance was changing [2, 3, 5].

Description of wireless system

There is a lot of wireless techniques available in the market that differ frequency band, maximum radiated power, maximum radio baud rate etc. Properties and parameters of mostly applied wireless techniques are presented briefly in table 1.

Table 1. Comparing of the most popular wireless techniques [4]

Parameter		Wireless techniques				
		GSM	TETRA	WiFi	Zigbee	ISM 868
Band or range of frequencies	MHZ	900/1800/1900	400	2400 – 2483,5 5725 – 5875	868-870 902-928 2400-2483,5	869,4-869,65
Maximum power of signal	W	8[1)]	10[1)]	1	0,1	0,5
Maximum range	km	35[2)]	60[2)]	10	0,1	4
Maximum radio baud rate	kb/s	384	28,8	54000	250	150
Required license of transmitting	-	YES	YES	It depends on maximum power and country	NO	NO

[1]This value is given for mobile terminals
[2]Range relates to area of one base station in build-up area

Techniques of wireless transmission of data has to be chosen appropriately to the properties of measured object. Criteria of selection appropriate wireless technique are following:

- regulations of country affected of frequency bands without license,
- appropriate frequency,
- maximum power of signal for given frequency band,
- maximum radio baud rate transmission that it is used by devices of wireless technique,
- security of transmitted data,
- possibility of battery supply,
- availability of devices in modular form,
- kind of transmitted data, for example video, audio or text files,
- maximum number of devices working in area of one system,
- possibility of work of system when base station is damaged,
- cost of system [4].

The radio modules for 868 MHz frequency was chosen using above mentioned criteria because they work in unlicensed band, maximum radiated power of transmitted signal is 500 mW and therefore maximum range is 4 km in line of sight of transmitter and receiver. These radio modules enable easy enlargement of system, communicate with computer using RS-232 interface, can be supplied from battery, don't require communication with base station and have maximum radio baud rate up to 150 kb/s. Elements of wireless breath monitoring system is presented in figure 1.

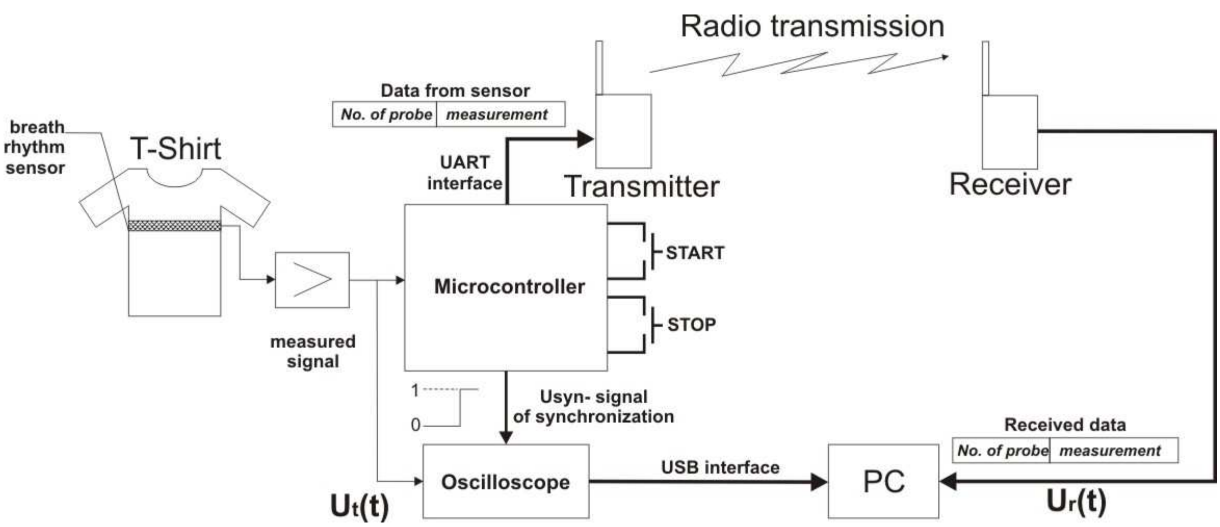

Figure 1. Wireless breath monitoring system

Breath rhythm sensor is made of electroconductive yarn. The sensor is connected to input of amplifier. When human chest moving the resistance of sensor changes. It causes change of output voltage of amplifier. Signal from amplifier $U_t(t)$ is measured by A/C converter of microcontroller and oscilloscope. The microcontroller acquire values from sensor and prepare data for transmission through transmitter. The transmission is carried out by radio link. The data is received by receiver and is collected by computer. Data from sensor consists of No. of probe and value of measurement. Microcontroller sends digital signal of synchronization. This signal enables to synchronize of sent data $U_t(t)$ with received data $U_r(t)$. Data acquired by digital oscilloscope are sent to the PC using USB interface. This data are compared with received data from receiver. Received data are collected and displayed in software. Wireless breath monitoring system with software was designed and made by Department of Clothing Technology and Textronic, Technical University of Lodz.
The software displays measured data with format time (h :min :s :ms), number of probe and measured voltage. Data can be written to the file. Measurements can be started and stopped by pushing Start measurement and Stop measurement. Trace with probes was drawn in Excel software using text data written to the file.
Pushing of “Start” switch launches a transmission of data from transmitter, probe of measurement starts from No. 1, U_{syn} is set in high state and data from sensor are collected by oscilloscope. When “Stop” switch is pushed, transmission and collecting data from sensor is stopped and U_{syn} is set in low state.
Parameters of transmission are following:

- power of signal: 25 mW,
- distance between transmitter and receiver 20 m,
- radio baud rate of data 38 kb/s,
- interval of time between sending two near probes 100 ms.

Research

Breath rhythm sensor was tested on user in following conditions:

1. Normal breath in standing position,
2. Normal breath in sitting position.

Signal characteristic in time for mentioned conditions are presented in figures 2, 3.

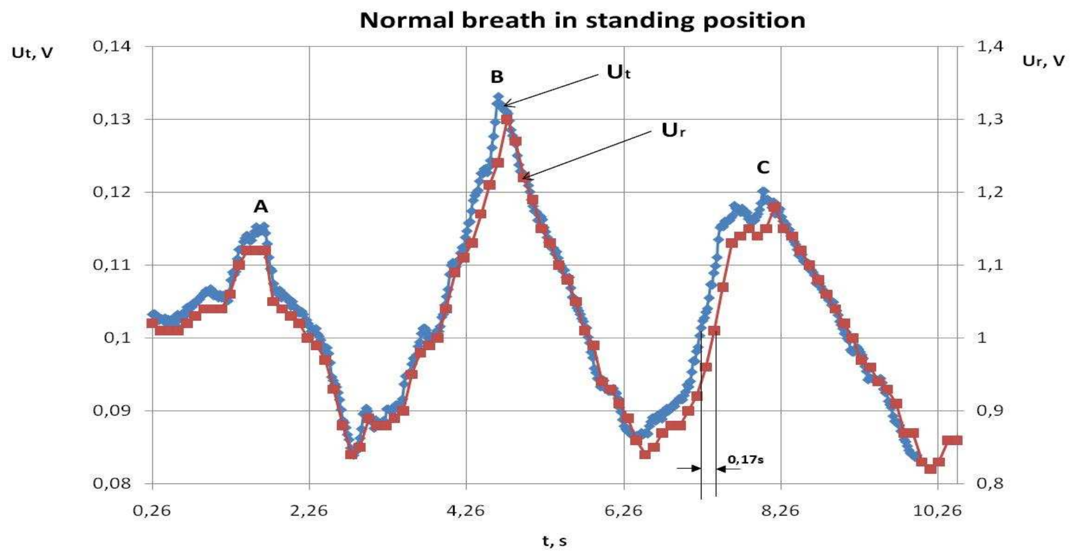

Figure 2. Normal breath in standing position

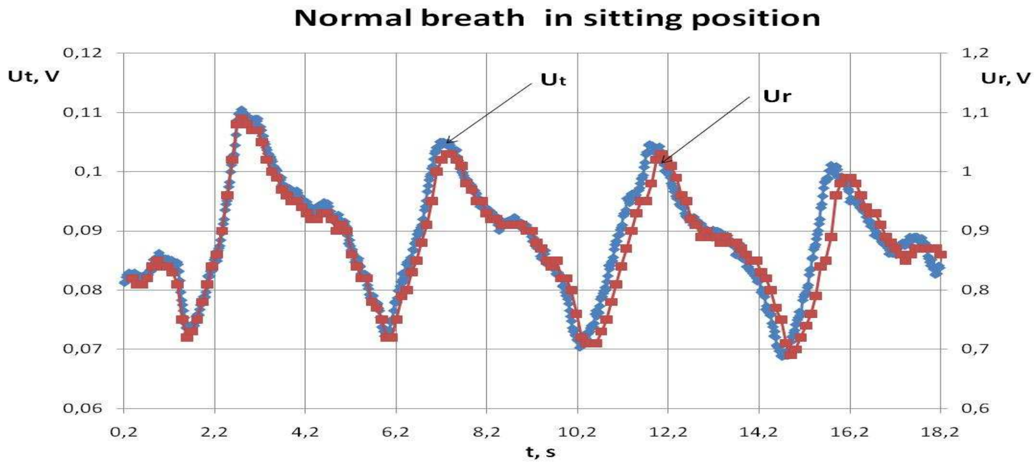

Figure 3. Normal breath in sitting position

Parameters like delay t_d between sent signal $U_t(t)$ and received signal $U_r(t)$ and breath rhythm rate "v" was read from above time chart. The breath rate was calculated to number of breath per 1 min and for sent data v_t and received data v_r. Calculation method of breath rate is presented in figure 2. Peaks of chart A, B, C (figure 2) is counted in given time and then are calculated in 1 min. Time of delay t_d is determined as greatest value. Table 2 presents results of research.

Table 2. Results of measurements

Case	t_d	v_t	vr
	s	number of breaths/min	number of breaths/min
1. Normal breath in standing position	0,17	18	18
2. Normal breath in sitting position	0,21	13	13

Conclusions

Radio transmission is the only way of communication, if signal from textronic garment has to be sent outside. Research of transmission data from breath rhythm sensor was carried out in transparent mode. The data in this mode are not secured. There is small delay between sent and received data from breath rhythm sensor. Delay is caused by receiver and software that read data from receiver. This software introduce additional delay, because received buffer of RS232 of PC first has to be clear and then information is read.
Shapes of sent and received signal are similar but not the same, because frequency of sampling of these signal is different. Interval of time sampling is 20 ms for data read by oscilloscope $U_t(t)$ and 100 ms for data sent by transmitter.

Reference:

1. Gniotek K., Stempień Z., Zięba J.: Tekstronika – nowy obszar wiedzy, Przegląd Włókienniczy, nr 2, 2003, s. 17
2. Frydrysiak M., Włodarczyk B., Zięba J., Kowalski K., Tekstroniczny, bezszwowy wyrób dziany do monitorowania częstości oddechu, IX Międzynarodowa Konferencja

Naukowo-Techniczna, Knitt Tech, Innowacyjne techniki i technologie w dziewiarstwie, Rydzyna 2010, ISBN 978-83911012-9-2,

3. Zięba J., Frydrysiak M., Gniotek K.: Textronics System for the Breathing Measuring. Fibres & Textiles in Eastern Europe (ISI), Vol. 15, No 5 , 2007, (64)
4. Tęsiorowski Ł., Gniotek K., Radiowa transmisja sygnałów w systemie tekstronicznym, Przegląd Telekomunikacyjny i Wiadomości Telekomunikacyjne, Nr11, 2008, s.1048–1051
5. Krupa J., Musiał A., Zięba J., Frydrysiak M, Desing and experimental research of textile sensor for selected physiological human parametrs, Innovations in Clothes and Footwear, Monografics series Volume XIII, Leather, clothing and footwear desing, materials and technology, edited by, Maria Pawłowa, Wydawnictwo Politechniki Radomskiej, Radom, 2010, p 215-222.

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