Non invasive monitoring of the cardio respiratory activity

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Abstract— **The paper presents the results regarding the application of the microwaves and ultrasounds technology for realizing new types of sensors for the detection of the cardio respiratory activity. In the present paper are presented the performances of the biosensors, the functional characteristics and is made a evaluation regarding the compatibility with the human body. Both types of biosensors allowed the detection of two types of breathing: the thoracic and the abdominal one. As a reference transducer we used a piesoresistive sensor as reference. A good correlation was established between the two transducers and reference sensor. The method used can detect without any contact with the patient the breathing rate and the apnea appearance. The two detectors use different work principles: one detects the speed of the anatomical structures, the other one the movement of the human body. There were identified signals made by the cardiac activity and respiratory signals.**

Keywords— **microwave, ultrasounds, non-invasive monitoring, cardio-respiratory activity.**

I. INTRODUCTION

The cardio-respiratory activity is an important parameter for the observation of the human body activity. A normal adult have a respiratory rate of 12 - 15 breaths/minute in normal conditions, inspiring and expiring 6-8 liters of air/minute. The absence of breathing, apnea, represent the stoppage of the air flow which passes throw the nose or throw the oral cavity to pass to the lung, for an interval longer than 20 seconds.

It is difficult to forecast the absence of the breathing which can be deathly in a few minutes. The mortality caused by the acute cardio respiratory diseases or the absence of breathing is significant, counting that the absence of the normal cardiac activity during the sleep phase can be also preceded or combined with the absence of breathing.

II. CLINICAL MONITORING METHODS

Actually, the monitoring of cardio respiratory activity is made by the direct contact with the patient by placing the respiratory abdominal and thoracic sensors (strain gauge, capacitive sensors for movement), pulse (photo plethysmograph or pulse oxymeter) and for the detection of the heart bioelectric activity are used skin electrodes connected to an ECG monitor.

Concerning the methods and respiratory monitoring activities devices for different physiological parameters, reported in the literature, three categories of sensing principles are further presented and described.

There can be detected the following parameters:

- the movement and the thorax and abdomen volume, with sensors placed on the human thorax or abdomen;
- airflow detection, with sensors placed in front of the nose and the oral cavity;
- the detection of the composition of the gases from the blood, using sensors for detecting the concentration of gases from the blood.

For applying these methods are used the following techniques [1]:

1. Movement, volume and tissue composition detection, the used methods in this category are: the trans thoracic impedance monitoring with skin electrodes on chest, inductance plethysmography by using embedded coils around abdomen and chest, the strain gauge transducers by using resistive strain gauge around abdomen and chest, the mutual inductance method by using magnets on chest, the microwave method by using a microwave sensor, the electromyography by using skin electrodes, the photopletysmography by using fiber optic sensors.
2. Airflow sensing can be detected because the expiratory air is warmer, has higher humidity and contains more CO_2 than inspiratory air. The methods used in the airflow sensing are: the temperature sensing by using temperature sensors, the humidity sensing by using hygrometer or fiber optic sensor in or in front of nose/oral cavity.
3. Blood gas measurement can be made by pulseoximetry, transcutaneous CO_2 measurement by using chemical sensors.

III. EXPERIMENTAL SETUP

The installation for the comparative study of three types of transducers for detecting the respiratory activity is presented in figure 1; we used two types of movement transducers – with microwaves [2] and ultrasounds [3]:

- Doppler movement transducer with microwaves;
- Movement transducer with ultrasounds interferometer;
- Transducer type resistive belt as a reference element.

The subject was placed on a bed, lieing in a relaxant position. The resistive transducer was connected to a Wheastone bridge. The microwave transducer was placed above the thorax, in different places following the map, in order to find the optimal signal (with the maximum

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amplitude) produced by the cardiac activity. Compared with the respiratory signal, that can be detected on the all surface of the thorax and abdomen; the cardiac activity can be detected in a specific area of the thorax.

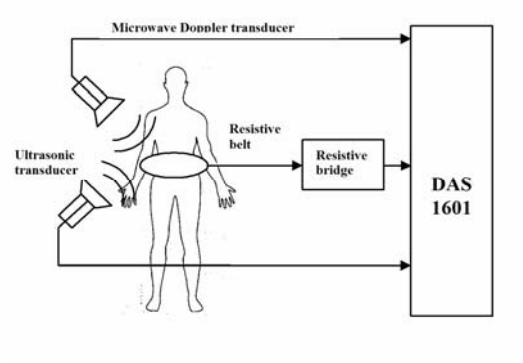

Fig. 1. Experimental installation for the study of the cardio respiratory activity with non contact transducers.

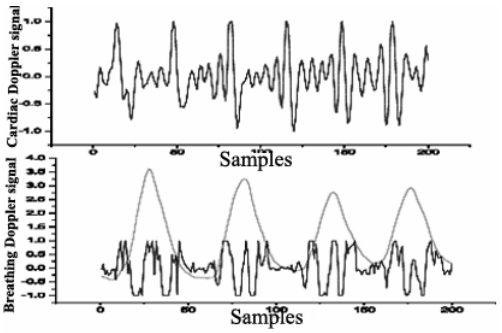

Fig. 2. Cardiac and respiratory activity detected using a microwave Doppler sensor

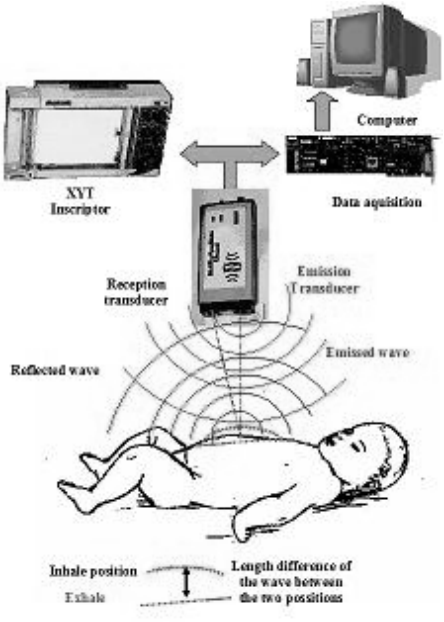

Fig. 3. Experimental installation for breathing monitoring with ultrasound sensor

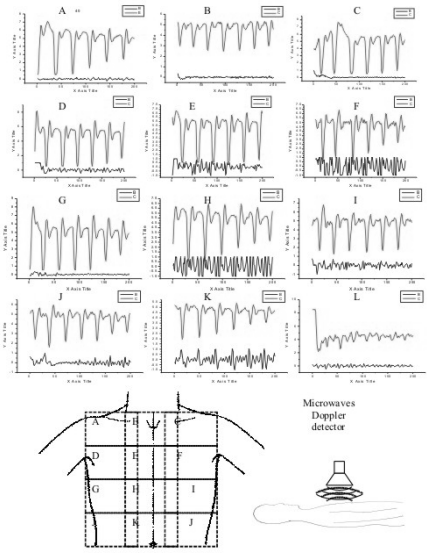

Fig. 4. Cardiac mapping detected by microwave sensor

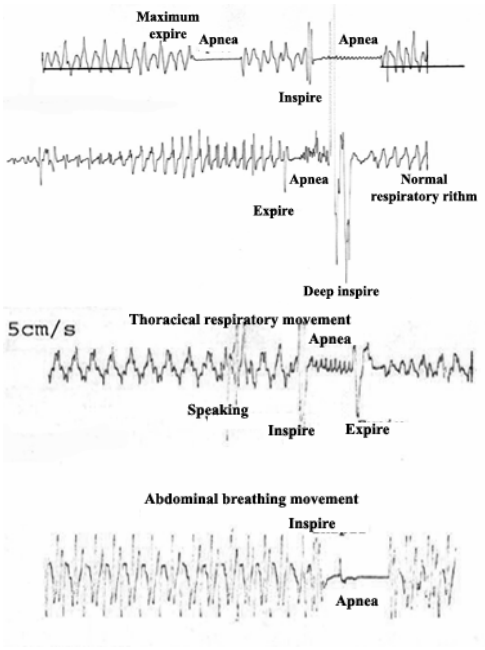

Fig. 5. Breathing signals using microwaves

IV. The Proposed Method: The Use of Ultrasounds and Microwaves

The use of *ultrasounds* in non-contact monitoring equipments of the respiratory activity is adequate because the ultrasounds are easy to generate and detect, their wavelength is relatively small compared to the thorax movement during a respiratory rate, their low energy and without negative consequences on the monitored subject. Based on the ultrasound interference has been developed a device that could be used for the non-contact respiratory rate monitoring

especially in the most difficult situation such us the prediction of apnea episodes.

The method is noninvasive, non-contact, non-dangerous radiations, and the device is easy to manipulate and the signal detected with this device can be visualized in figures 6 and 7 where can be clearly observed the signal of the normaly respiration rate and simulated of an apnea episode on a healthy adult subject.

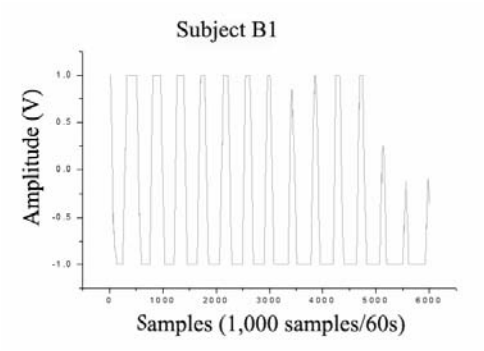

Fig. 6. Normal breathing signal from a healthy subject using ultrasounds

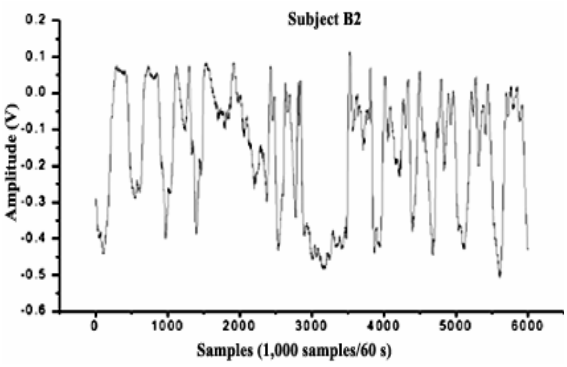

Fig. 7. Normal breathing signal with the apearence of apnea signal on a healthy subject using ultrasounds

The Doppler movement transducer with microwaves can detect record and interpret the signals produced by the cardio respiratory activity (fig.5). The method is noninvasive, without contact, without any risks, allowing also the separation between the signals from the cardiac activity and the signals caused by the respiratory activity. The transducer with microwaves uses the Doppler Effect for detecting the complex movements made by the anatomical structures of the thorax and abdomen, caused by the cardio respiratory activity. The respiratory activity is recorded using a transducer type resistive belt fixed on the circumference of the thorax. This is the fourth channel for measuring and allows the achievement of some information regarding the amplitude and frequency, and also the records of the apnea after expire or inspire.

V. Experimental results

Concerning the cardiac activity, the monitoring is realized by using classic monitors, with skin electrodes connected to ECG monitors. Although ECG offers the most complex information, it is necessary to monitor the heart activity by using the rate detection. Our non-contact and noninvasive method allows the cardio respiratory activity detection cheaper than ordinary monitor. Partially, this fact is made by artifacts but some external noises that are present are difficult to predict and to eliminate.

VI. Conclusions

The experimental results confirm the possibility to use a microwave Doppler detector of motion for detection, recording and explaining the signals produced by the cardio-respiratory. The method permits to detect the apnea condition, the breathing frequency, as well as the heart activity. The radiant energy is much below the admitted limits [4]; the energy density at the horn antenna output is 0,03 mW/cm^2. One can also remark a good correlation between the complex Doppler signal and the ECG signal, the breathing and the pulse photoelectric transducer.

VII. References

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