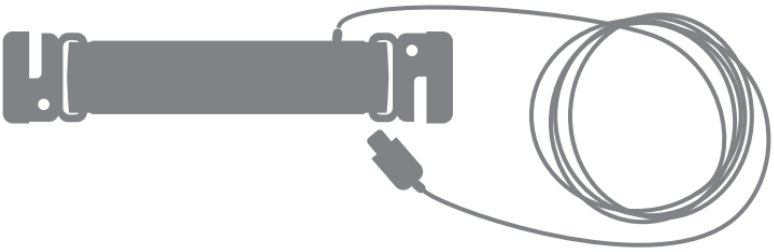
Respiration Signal Processing

Tutorial Guide



Respiration Signal Processing

The respiratory system is responsible for gas exchange, transporting oxygen to inner body in inspiration and eliminating carbon dioxide during expiration. All this process has the aim of oxygenate the blood inside the lungs to maintain the cellular survival.
In the process of breathing underlies the expansion and the contraction rhythmic called respiratory cycle, which is characterized by a typical rate between 16 and 20 per minute in adults, being higher in children. In case of deep breaths, the normal rate is 6 per minute.
One of the methods to obtain the respiration biosignal is mechanorespirogram. It requires the use of a belt around the chest. During respiration, the elastic suffers an extension or contraction compared to its initial position and this mechanical tension is converted into voltage by a piozoelectric transducer.
Figure 1 represents the behaviour of the respiration wave. As can be seen, the signal rises on inspiration and declines on expiration. The sensor properties and characteristics are attached to this document.

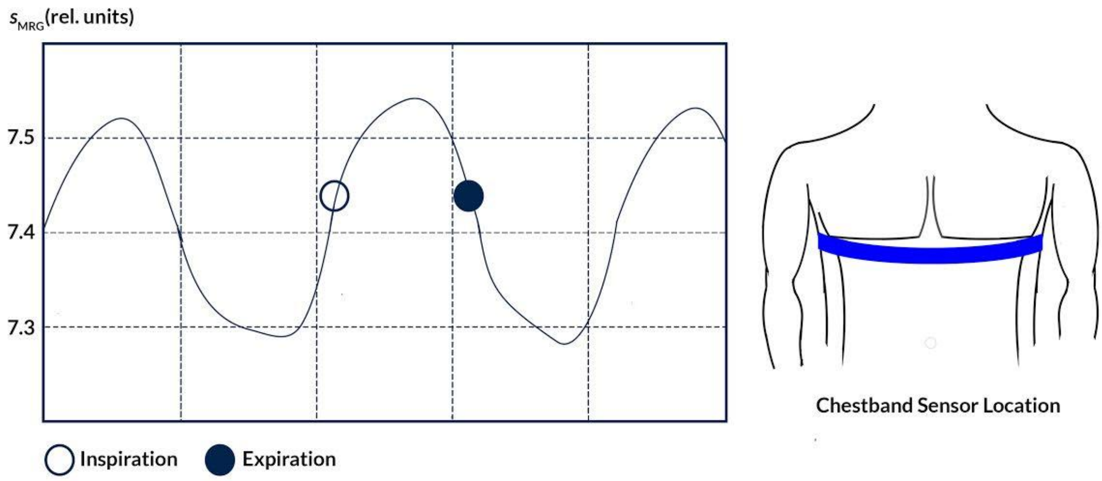


Figure 1 – Respiration signal result by mechanorespirogram method.

This guide provides step by step instructions to acquire the respiration signal and to process it result, in order to obtain the mean wave and its parameters, which could have an important role, for example, to detect outliers.

1. Put the respiration belt around your chest. Adjust it to fit comfortably and to not be too tight to avoid the signal saturation;
2. Open the Open Signals;
3. Begin the signal acquisition. Try to stay quiet and choose to breathe deeply or normally (just one of them); Figure 2 shows an example of an acquisition.
4. After one minute stop the acquisition and save the result;
5. Open the python and import *novainstrumentation*;
6. Open the recorded signal using the function *loadtxt*;
7. To obtain the filtered signal use the function *respFilt*. This function receives the smooth filter window (usually 300);
8. To detect the start of expiration use the function *getExp*. This function receives a threshold (usually 1);

9. To detect the start of inspiration use the function *getInsp*. This function receives a threshold (usually 0.01);
10. You should verify the detection of all the expirations and inspirations plotting the filtered signal with these points marked. Figure 2 shows an example of this plot.
11. To extract the mean wave with its parameters marked use the function *respmw*. Figure 3 shows an example of this wave.

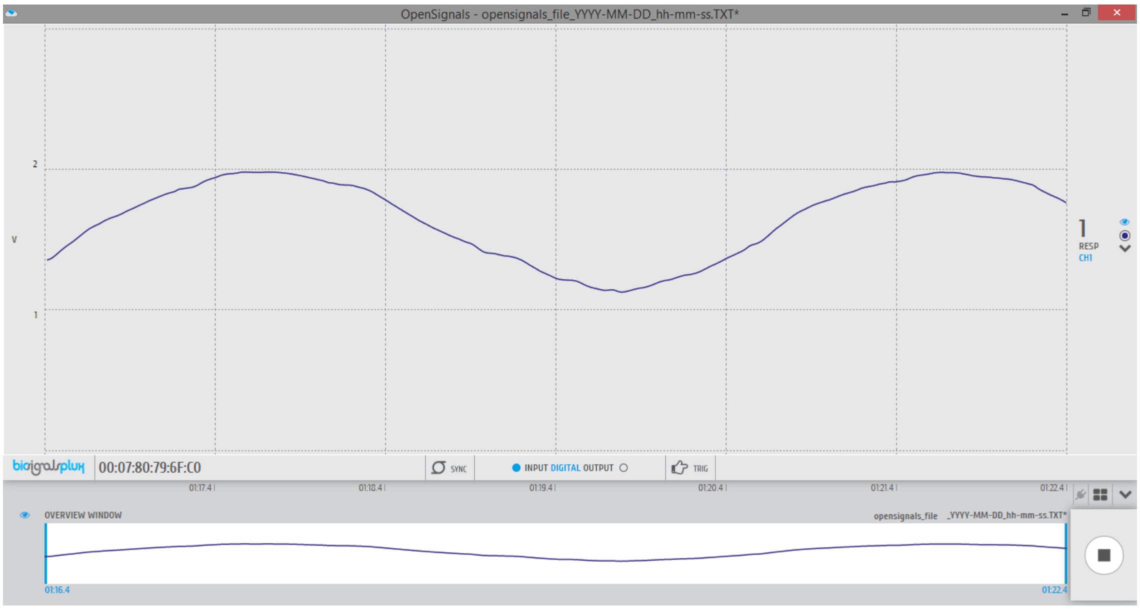


Figure 3 - Respiration signal acquisition by Open Signals.

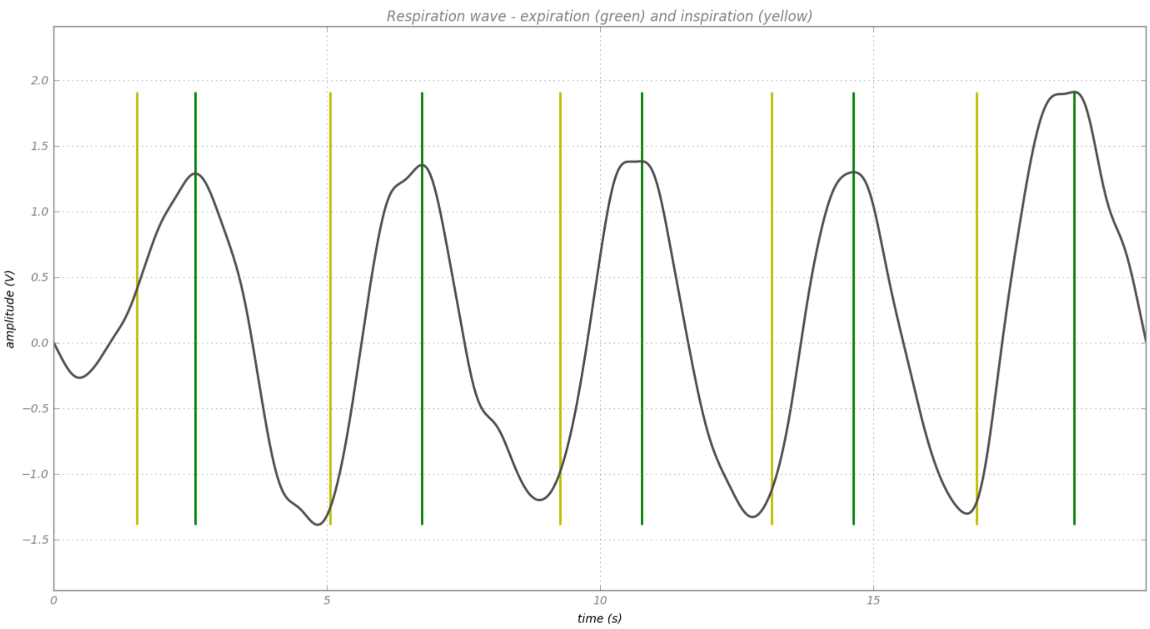


Figure 2 – Filtered respiration wave. The yellow lines represent the beginning of inspiration and the green the beginning of expiration.

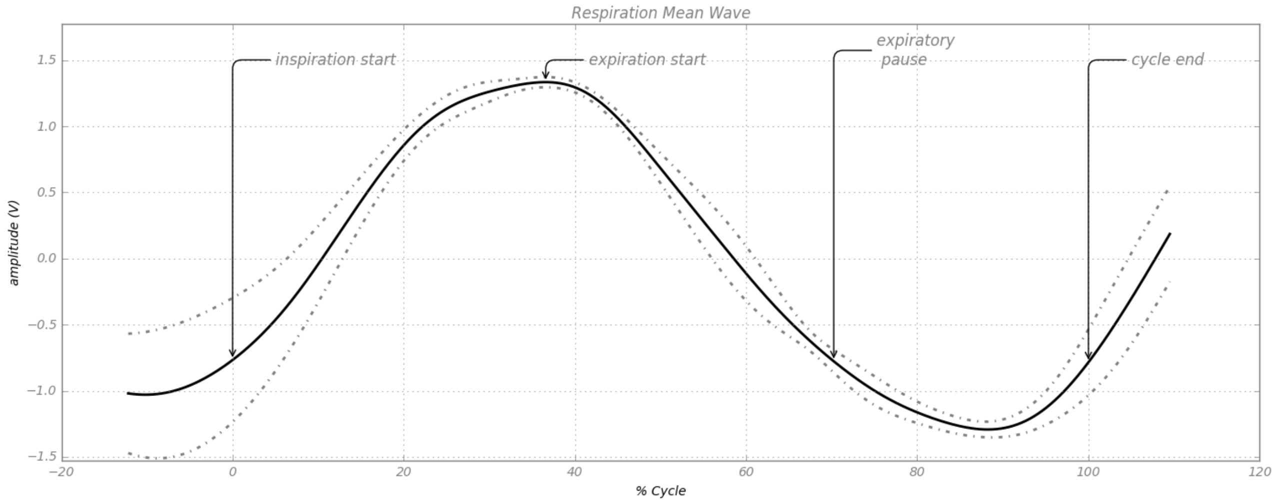


Figure 4 - Respiration mean wave and its parameters.

respPlux Respiration Sensor

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Fig1: respPlux Respiration Sensor.

Description

Respiration signals are directly or indirectly related to the lungs' volumes along each breath. Indirect measures of respiration can be taken by using our respiration sensor which integrates a Piezo Film Technology (PVDF) sensor. This sensor measures the length changes related to the abdominal and thoracic movements obtaining a respiration signal with high sensitivity and low noise where respiratory cycles can be observed.

Applications

Some of the applications of this sensor include thoracic cavity displacement measurement and respiratory cycle's observation. Diagnosing sleep disorders, such as sleep apnea, characterized by pauses in breathing or abnormally low breathing during sleep. Also use the respiratory monitoring in athletes to determine ventilation levels and study the relation with their performance.

Characteristics of respPlux Respiration Sensor

respPlux Respiration sensor				
Parameter	**Min**	**Typ**	**Max**	**Units**
Gain	-	1	-	NA
Bandwidth (Version A)	0.0058	-	2,8	Hz
Bandwidth (Version B)	0.0058	-	0,9	Hz
Operating Temperature	-35	-	+85	ºC
Cable length (A1)	-	105 ± 5	-	cm
Wire type	-	36AWG	-	NA
Wire isolation	-	PFA (PerFluoro Alkoxy)	-	NA
Color sleeves (S)	-	Blue / Green / Red / Yellow / Gray / Brown / Black / White	-	NA

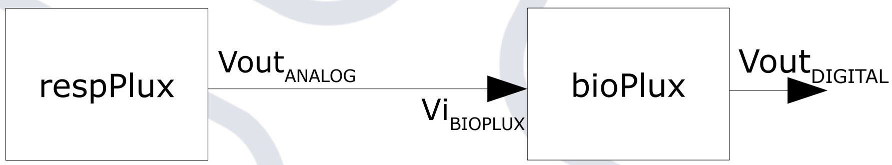
Table 1: respPlux sensor characteristics

Acquisition, conversion example and transfer function of respPlux sensors

The process begins with the user making an acquisition with one of respPlux Respiration sensors and bioPlux. When finished, the acquisition session must be saved with Monitor Plux in a text file.

The bioPlux system acquires all sensor signals with a voltage range between 0 and 3 Volts. 0V corresponds to the digital value 0, and 3V corresponds to the digital value 4095 (an unsigned 12-bit integer). A variation in these digital values, corresponds to an analog signal voltage variation at the bioPlux inputs. The next step is to know the physical meaning of the signal voltages. To do this, the transfer function must be known, for of each type of sensor.

The half-scale of the respPlux sensor (static signal) is about 3V / 2 = 1,5 V, or a digital value of about 4096 / 2 = 2048. The voltage gain of this sensor (i.e., the ratio between the output signal for the bioPlux and the input Respiration signal) is 1. The diagram and equations (1.1) and (1.2) follow this line of thinking:



$$V_{out_{ANALOG}} = V_{i_{BIOPLUX}} = V_i \times 1 + 1.5 \qquad (1.1)$$

$$V_{out_{DIGITAL}} = \frac{V_{out_{ANALOG}} \times 4095}{3} \Leftrightarrow V_{out_{ANALOG}} = \frac{V_{out_{DIGITAL}} \times 3}{4095} \qquad (1.2)$$

Ordering Guide and final notes

The respPlux model is designed to be interchangeable within the interval of -35ºC to +85ºC. For a better overall stability, the storage and work temperatures should be maintained below +70ºC.

Sensor Name : respPlux

Reference : Resp1 A / B

Please choose the sleeve color from the upper table.

Publications

R. Chorão, H. Gamboa. Parallel Programming in Biomedical Signal Processing. Master thesis at FCT/UNL 2012.

R. Abreu, J. Sousa, H. Gamboa. A Signal-independent algorithm for information extraction and signal annotation of long-term records. Proceedings of Biosignals - 6th International Conference on Bio-Inspired and Signal Processing (BIOSIGNALS 2013), Barcelona, Spain, 2013.

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J.A. Dempsey, S.C. Veasey, B.J. Morgan, and C.P. O'Donnell. Pathophysiology of sleep apnea. Physiological reviews, 90(1):47–112, 2010.

D.T.H. Lai, R. Begg, and M. Palaniswami. Healthcare Sensor Networks: Challenges Toward Practical Implementation. CRC Press, 2011.