respiBAN BLE

Datasheet

respiBAN BLE
Designed & Made in Portugal

Table of Contents

For a getting started guide, visit the following article:
https://support.pluxbiosignals.com/knowledge-base/respiban-ble-getting-started/

For support visit
www.support.pluxbiosignals.com

RESPIBAN BLE (2024)

General Information

Introducing respiBAN BLE, your go-to wireless wearable for hassle-free respiration and motion data collection.

Designed with your comfort in mind, respiBAN is the solution for seamless research in any setting. Say goodbye to bulky, uncomfortable devices — respiBAN is designed to ensure user comfort, even during dynamic activities. Plus, it's ready to use as a medical device OEM, and you can jumpstart your work. Talk to our team for more information.

Specifications

> On-Board Sensors:	1x Inductive Respiration Sensor 1x Triaxial Accelerometer 1x Triaxial Gyroscope
> Sensor Ranges	Respiration: 540nH to 47uH (converted into rel. changes) Accelerometer: ±8g Gyroscope: ±500dps
> Communication:	Bluetooth Low Energy (BLE) (v.5.3)
> Communication Range:	Up to 10m (in line of sight)
> Internal Memory:	Up to 10h
> Battery:	Rechargeable 155mA 3.7V LiPo
> Battery Lifetime:	Up to 10h in continuous streaming
> Charging Port:	Micro-USB compatible with an standard USB Charger
> Size:	31x71x11mm
> Weight:	27g

Features

> Wearable for single-channel Respiration & motion data acquisition
> Respiration measurement, including apnea detection
> Respiration measurements with inductive sensor; intrinsically electrical isolated from the body

> Raw signal acquired at 400Hz
> Miniaturized and bendable form factor for better adaption to the body shape

Applications

This product is designed for life science education and research. It is not a medical device and is not suitable for any kind of medical use.

> Respiration recording, respiration rate extraction & motion data extraction
> Life sciences studies
> Biomedical research
> Human-Computer Interaction
> Robotics & Cybernetics
> Physiology studies
> Psychophysiology
> Biomechanics
> Ergonomics

Electrical Specifications

	Respiration	ACC	GYR
Number of channels	1	3	3
Resolution	28 bit	16 bit	16 bit
Input full-scale*	540nH to 47uH	+/-8G	+/-500dps
Analog bandwidth	[DC to 200Hz]	[dc to 415Hz]	[dc to 315Hz]
Sample rate	400 Hz	400 Hz	400 Hz

* In PLUX software converted into relative changes around the signal's baseline

Application Notes

A detailed Getting Started guide covering everything needed around the cardioBAN is available on our support page:

https://support.pluxbiosignals.com/knowledge-base/respiban-ble-getting-started/

The respiBAN should be used with the inductive band that comes with your wearbale.

Respiration Belt Positioning

The respiration belt can be placed around the thorax or abdomen for abdominal or thoracic respiration recordings.

For thoracic respiration, place the respiration belt around the thorax around the nipple line. For abdominal respiration, place the respiration belt below the ribcage.

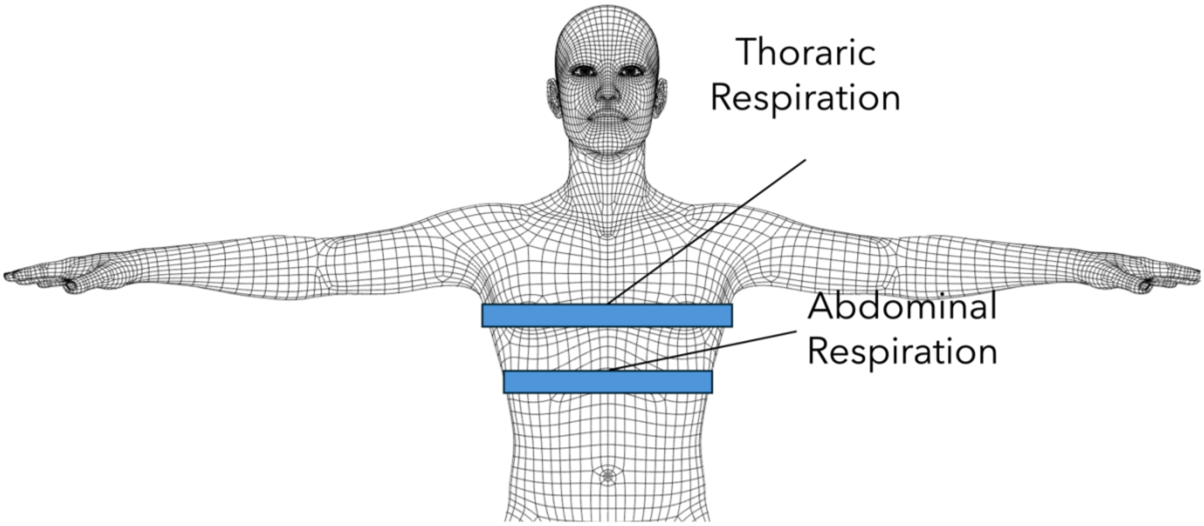

Figure 1: respiBAN belt positioning options

Follow these intructions for best signal recording results:

1. Place the respiration belt around the thorax or upper abdomen
2. Fixate the belt using the velcro bands at both ends of your respiration belt
3. Adjust the belt to the size of your body. The respiration should be set tightly yet comfortably to ensure good signal recordings.
4. Place the respiBAN wearable on the respiration belt by connecting the female stud connectors on the back of the device to the male stud connectors of the respiration belt.

Figure 2: Backside of the respiBAN wearable with the two stud connectors.

Motion Sensor Axes & Orientation

respiBAN comes with built-in triaxial Accelerometer and Gyroscope for motion sensing. The default axis layout for the triaxial motion of the Acceleroemter is set as follows:

Figure 3: respiBAN motion sensor axes.

Depending on the orientation of your sensor, the axis can change. It's recommended to test the orientation of your respiBAN with your sensor data to identify the matching signals. In an Accelerometer, the most prominent axis to identify is the vertical Z-axis, which is naturally offset by approximately 1G because the Earth's gravitational force accelerates along this axis.

LED Color Codes

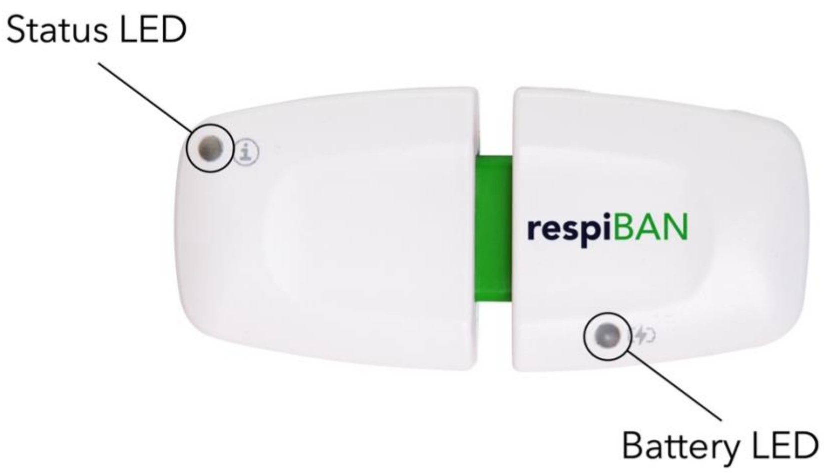

Figure 4: respiBAN's feedback LEDs

System LED States

State	Description	LED effect
OFF	The device is switched off	Off, no lighting effect
IDLE	The device is turned on and waiting for some interaction.	Blinking yellow at 0.5Hz
IDLE + SCHEDULED	The device is turned on and waiting for some interaction, but it has a schedule loaded in memory to start an acquisition.	Alternates between yellow and blue at 0.5Hz
IDLE + CONNECTED	The device is turned on and waiting for some interaction, but a BLE Bluetooth connection has been established with a host machine.	Blinking green at 0.5Hz
IDLE + CONNECTED + SCHEDULED	The device is turned on and waiting for some interaction. It has a schedule loaded in memory to start an acquisition. A BLE Bluetooth connection has been established with a host machine.	Alternates between green and blue at 0.5Hz
START_ ACQUIRING	The device has started an acquisition.	Fast blinking blue at 5Hz during 1 second
ACQUIRING	The device is in aquation mode.	Blinking blue at 0.5Hz
ERROR	The device is in an error state.	Blinking red at 2Hz

Battery LED States

State	Description	LED effect
NORMAL/CHARGED	The LED being off occurs in two situations: (a) Device has an appropriate charge level for its operation. (b) Device is fully charged.	Off, no lighting effect
CHARGING	Device is charging	Solid red, always on
LOW_BATT	The device's battery level is getting low; it is recommended to put the device on charge.	Blinking red at 1Hz
DISCHARGED_BATT	The device's battery level is critically low. The device must be charged immediately.	Blinking red at 10Hz

Transfer Functions

Electrocardiography (ECG) Sensor

The respiration value range = [540nH, 47uH]

$$L_{Respi}[H] = \frac{L_{Respi_{fH}}}{10^{15}}$$

Where:
L_{RESPI_fH} – Value returned by the device in [fH]

Note: Inductive straps used for measuring breathing typically have nominal inductance values when unloaded of around 2 µH to 5µH.

This nominal unloaded value changes by approximately 1% to 3% during a breathing cycle. In PLUX software, this the L_{RESPI_fH} value is converted to a relative change around the signal baseline for an easier-to-understand measure compared to the absolute values in nH or uH. See the software documentation for further details.

Accelerometer

Range: [-8G, 8G]

$$Acc(g) = \left(ADC - \frac{2^n}{2}\right) \cdot \left(\frac{16}{2^n}\right)$$

$Acc(g)$ – Accelerometer value in g
ADC – Value sampled from the channel
n – Number of bits of the channel[1]

Gyroscope

Range: [-500dps, 500dps]

[1] *The number of bits for each channel depends on the resolution of the Analog-to-Digital Converter (ADC); in cardioBAN the default is 16-bit resolution (n=16)*

$$Gyr(dps) = \left(ADC - \frac{2^n}{2}\right) \cdot \left(\frac{1000}{2^n}\right)$$

$Gyr(dps)$ – Accelerometer value in degrees per second (dps)
ADC – Value sampled from the channel
n – Number of bits of the channel[1]

Sample Signals

The following signals were recorded using respiBAN on a healthy individual under different breathing conditions.

Respiration Signals

The respiBAN's primary respiration sensor allows you to measure different types, rhythms, and intensities of respiratory patterns.

Normal Respiration

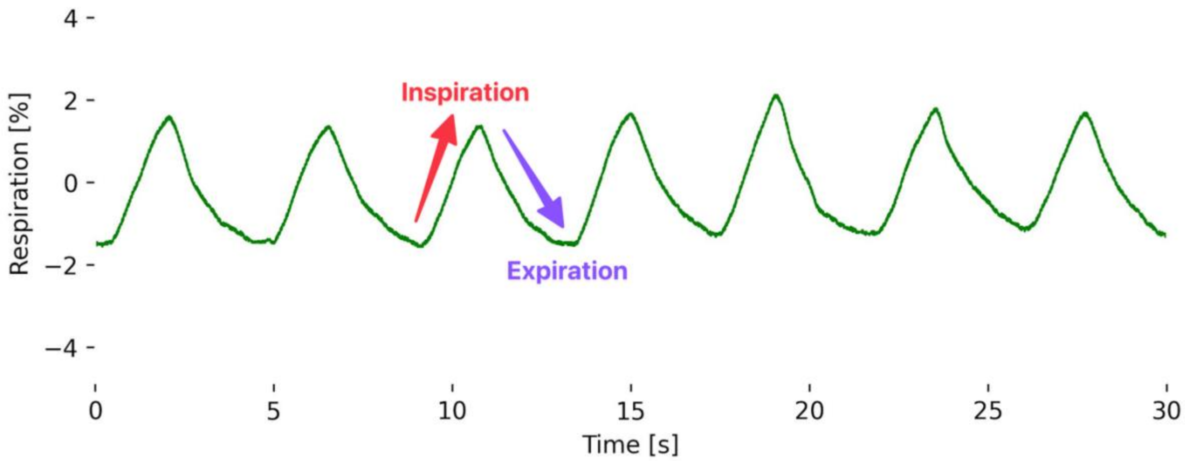

Figure 5: Normal respiration in respiBAN sensor data.

Respiration cycles in respiration signals are characterized by periodic peaks and valleys in the signal. Signal increases occur during the inspiration phase of the breathing cycle and peak at the maximum inspiration point. Signal decreases occur during the expiration phase of the breathing cycle and reach their minimum at full expiration.

During normal breathing, the frequency of the respiration cycles should be consistent with minor variations in length

Normal Respiration vs. Deep Respiration

Breathing intensities, such as normal vs. deep breathing, can be identified by changes in amplitudes of the respiration cycles.

The following plot shows the impact of normal breathing in breathing amplitudes against the increased amplitudes that occur during deep breathing.

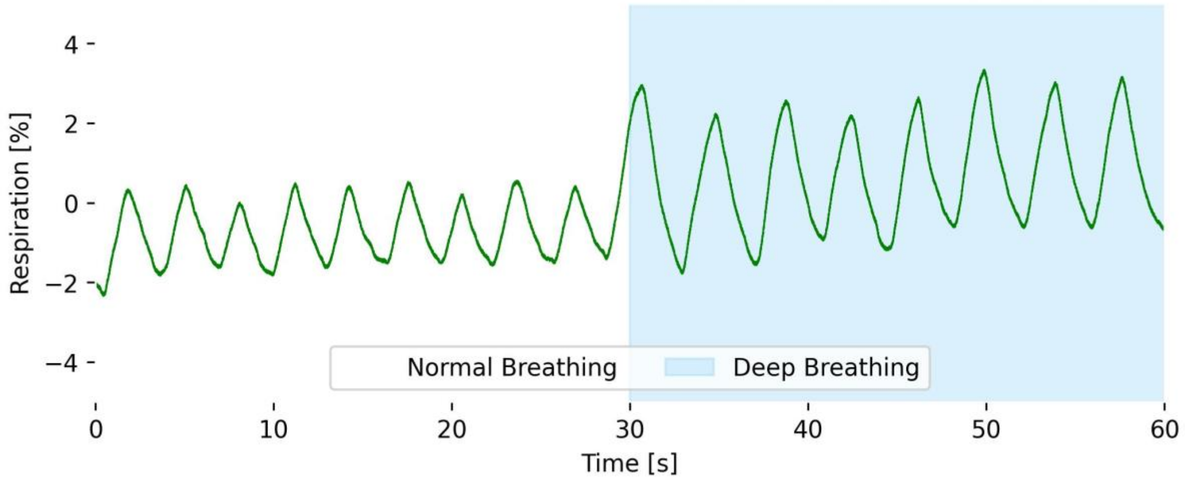

Figure 6: Normal & deep respiration in respiBAN sensor data.

Note that different breathing intensities can have other impacts on the signals that are of physiological nature. For instance, deep breathing is generally slower than normal breahting given the increased time needed to inhale and exhale the increased volume of air. In this cases, a change in breathing rate can be expected in addition to the amplitude changes.

Slow Respiration vs. Fast Respiration

Respiration can be identified by changes in the invtervals of the respiration cycles.

The following plot shows the impact of different breathing rhythms on the respiration signal, where the major change occurs in the frequency and duration of the respiration cycles.

Fast breathing shortens the interval of each respiration cycle and increases the cycle frequency. Slow breathing results in the contrary displaying longer intervals and reduced cycle frequency.

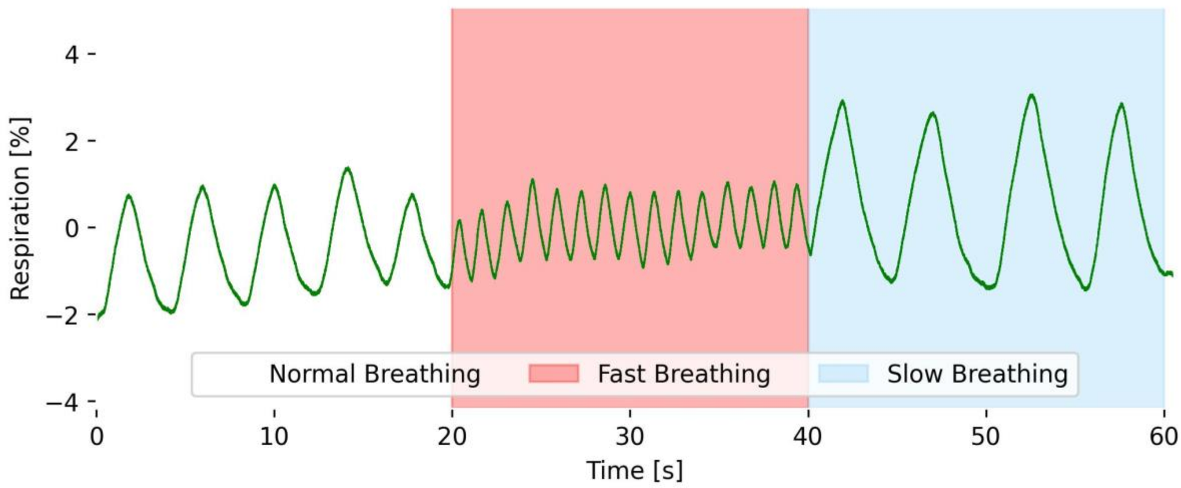

Figure 7: Normal vs. slow vs. fast breathing in respiBAN sensor data.

Note that different breathing frequencies can have other impacts on the signals that are of physiological nature. For instance, fast breathing results in generally lower signal amplitudes due to less air being inhaled and exhaled during the shorter respiration cycle. In this cases, a change in breathing amplitdude is expected in addition to the amplitude changes.

Apnea

Apnea is a temporary cessation of respiration. This can occur due to pathological reasons (e.g., sleep apnea, respiratory obstructions) or artificially induced by holding the breath.

Apnea in respiBAN sensor data is generally visible by the stagnation of the signal during the apnea phase. If the Apnea occurs at the end of an inspiration cycle, the signal remains at a (relatively) constant value near the respiration cycle's peak value. If the apnea occurs at the end of the expiration phase, the value signals remains at a (relatively) constant value near the respiration cycle's minimum value.

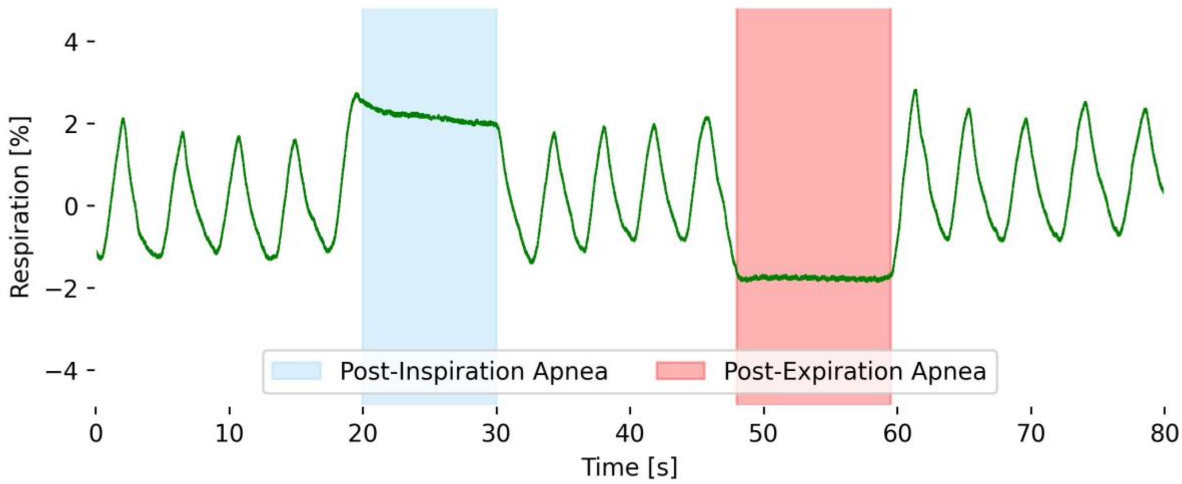

Figure 8: Apnea phases after inspiration and expiration in respiBAN sensor data.

In ideal setups, respiBAN sensor data stagnates at the last value at which a any stretching or relaxation of the respiration belt occurred, i.e. at the value at which any respiratory motion stopped. However, when working with real-subjects, no ideal setup of breathing mechanics occur, as natural breathing mechanics show minor deviations from this expected behavior.

As seen in the Figure above, an Apnea phase occurred after a deep inspiration (see *Post-Inspiration Apnea*), yet the value does not plateau at the peak of the respiration signal. Instead, it shows a minor decline during the apnea phase. This is due to the subject's natural breathing mechanics, as the artificially induced apnea (holding the breath) does not equal a complete block of the subject's respiration mechanics. Due to the increased air pressure within the lungs, air partially escapes from the lungs, thus changes the volume of the thorax or abdomen which reuslts in the minor decline of the signal.

Apnea phases are generally more stable in Post-Expiration apnea as in Post-Inspiration apnea.

Motion Sensors

respiBAN comes with built-in triaxial Acceleromter and Gyroscope to record motion data along with your respiration data.

Accelerometer

The Accelerometer measures acceleration along the three axes (x, y, z). The amplitude of the signal correlates with the acceleration that occurs along each axis.

In the following signal, this ampltiude change is visualized in the following intervals:

- 0s to 10s: No acceleration / movement
- 10s to 20s: Moderate acceleration / movement
- 20s to 30s: Intensive acceleration / movement
- 30s to 40s: No acceleration / movement

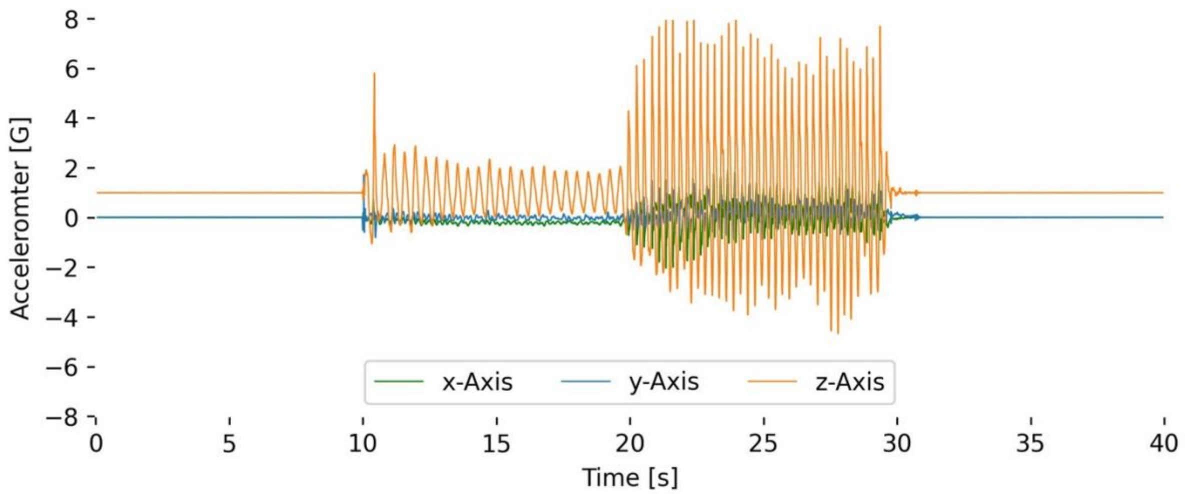

Figure 9: Motion data of different intensities in respiBAN Accelerometer data.

For further information about the orientation of the Accelerometer axis, see section Motion Sensor Axes & Orientation.

Gyroscope

The Gyroscope measures angular velocity, which is the rate at which an the respiBAN rotates around the axes (x, y, z). The amplitude of the signal correlates with the acceleration that occurs around each axis.

The following signals show the results of the Gyroscope when conducting the same motion pattern of the previous Accelerometer sample signal.

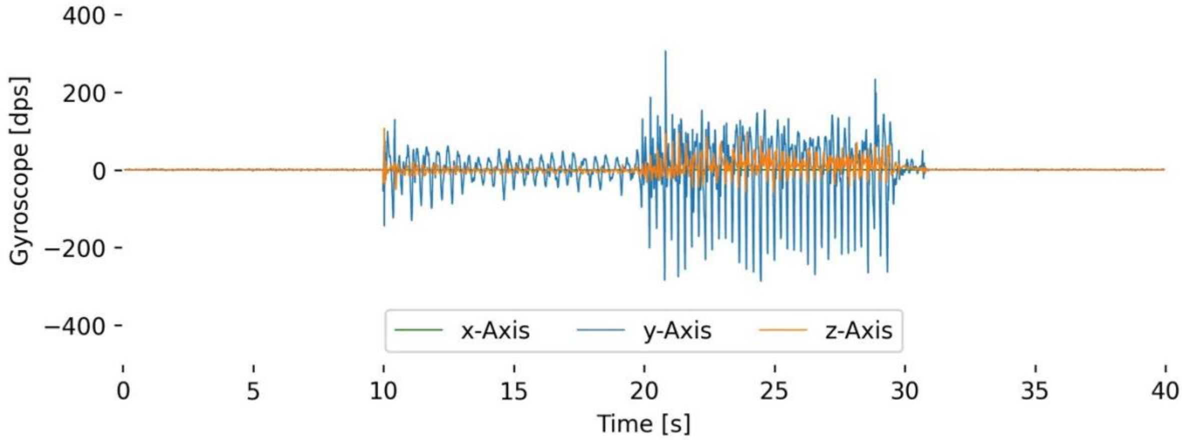

Figure 10: Figure 7: Motion data of different angular velocities in respiBAN Gyroscope data.

Disclaimer

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