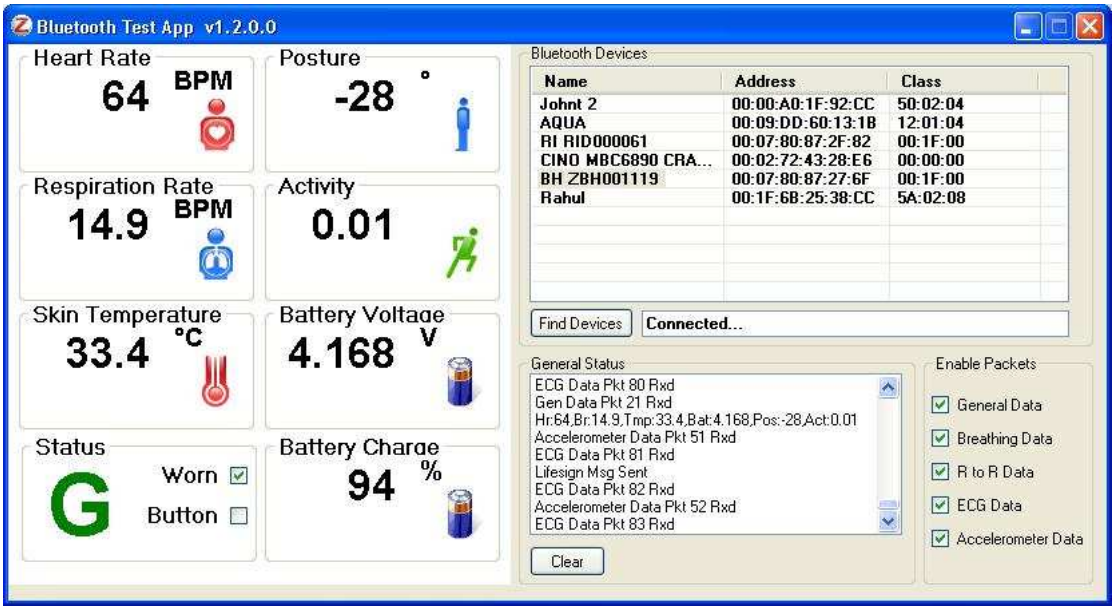
Zephyr
technology

BioHarness Bluetooth Developer Kit



User Manual

Contact

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Document History

Version	Date	Description
1.0	1 May 2008	Initial draft for review
1.1	7 May 2008	Data Descriptions section revised
1.2	4 June 2008	Add Troubleshoot Section
1.3	16 Sept 2008	New Test App GUI added
1.4	29 Oct 2008	BlueSoleil Version note
1.5	20 Nov 2008	Update to v1.2.0.0 of Test App grabs
1.6	23 Feb 2009	Update Test App. executable name Added ZPNs
1.7	9 June 2009	Clarify device RF/Log configuration throughout
1.8	28 Jan 2010	Add BT Config Tool
1.9	16 Mar 2010	Add new LED behaviour. Update data descriptions.
1.10	29 April 2010	Add ROG status behaviour
1.11	27 May 2010	Add Button Worn explanation
1.12	2 June 2010	Amend Refs to BT Comms Link doc, BT Logging Interface

Document Notes

All numbers in this document are written in decimal, except hexadecimal numbers which are prefixed by '0x'. For example 5436 is decimal, while 0x5436 is hexadecimal.

Contents

1. Introduction

1.1. References

Ref #	ID	Description
[1]	9700.0110	BioHarness Bluetooth Comms Link Specification.
[2]	9700.0027	BioHarness Bluetooth API Guide
[3]	9700.0111	BioHarness Bluetooth Logging System Interface

1.2. Abbreviations

Abbreviation	Description
ECG	**E**lectro**C**ardio**G**ram
GUI	**G**raphical **U**ser Interface
PC	**P**ersonal **C**omputer
ISM	**I**nstrument, **S**cientific & **M**edical Band (~900MHz radio frequency band)
ROG	**R**ed, **O**range, **G**reen subject physiological status indication

1.3. Product Description

The Zephyr BioHarness is a physiological monitoring system. The subject wears a Smart Fabric chest strap which incorporates sensors to monitor heart ECG signals, and respiration rate.

Attached to the strap is the BioHarness Module. This contains an infra-red temperature sensor for monitoring skin temperature, and a 3-axis accelerometer for monitoring attitude (subject posture) and activity (acceleration).

Raw sensor data is filtered, processed and analyzed within the device, which can operate in three modes. These modes are software configurable. The commands required to determine and set these modes can be found in the General Comms Link Specification document (sections 5.51 Get Bioharness User Configuration & 5.52 Set Bioharness User Configuration).

- Transmit mode
  Data is transmitted by Class I Bluetooth over a 10 meter range to a corresponding Bluetooth receiver device. This will allow physiological data to be monitored using any suitably-configured Bluetooth mobile device, such as a laptop, phone or PDA.

  A Bluetooth Test App is provided with the Developer Kit which displays transmitted data in real time. When the Bluetooth connection is terminated, the application generates .csv files containing the transmitted data.

- Record Mode
  Data is logged to internal memory. This data can be accessed when the device is placed in a cradle and connected via USB to a PC. A software utility (BioHarness Application) is provided which will allow import and display of recorded data from the device. This utility will also export recorded data to an external .csv file.

- Transmit & Record Mode
  Data is transmitted and recorded simultaneously. The two utilities mentioned above are used separately to display and record live streaming data, and download log data afterwards.

Note: Zephyr-supplied devices are configured to simultaneously transmit and log mode. They must be reconfigured using the BT Config Tool to disable either of these modes

1.4. Documents

1.4.1. BioHarness Bluetooth API Guide

This document contains detailed data descriptions, and specifies which messages apply to the Bluetooth Device

1.4.2. BioHarness Bluetooth Comms Link Specification

This document describes *all* Zephyr request/response messages. This is a superset of the messages specified in the API Guide.

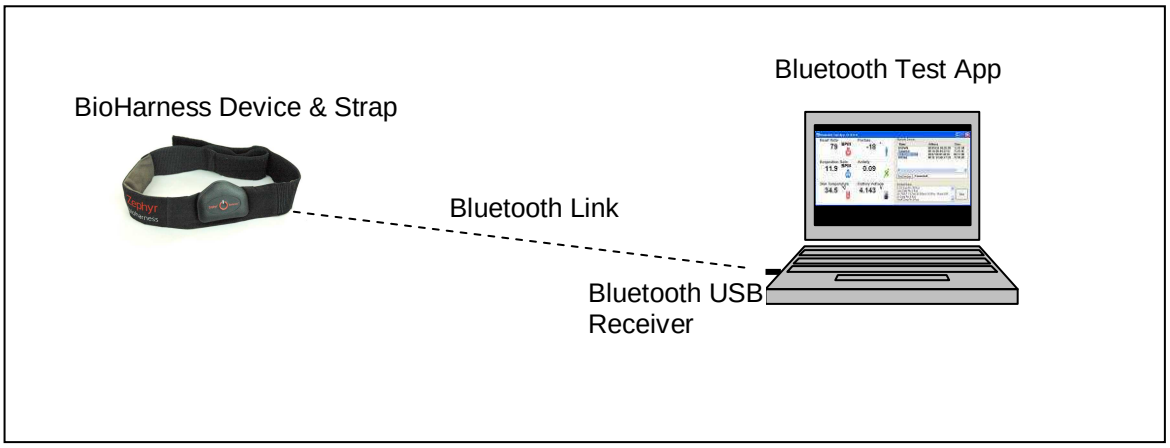
1.5. List of Components

The following components are included in the Developer Kit

Component	Description	Part No.
Hardware		
Smart Fabric Chest Strap	XS/S/M/L/XL sizes available	9600.0146 (XS) 9600.0116 9600.0115 9600.0114 9600.0145 (XL)
BioHarness Module		9600.0097
Bioharness Device USB Cradle		9600.0098
USB/USB-mini connector lead		0015.0003
CNet Bluetooth V2.0 USB Adapter Kit	Includes CD with Bluetooth Drivers, BlueSoleil Software & Manual	
Software		
Zephyr USB Driver	For connection of BioHarness Device to PC when charging or importing recorded data	9500.0003
Zephyr Bluetooth Test App	Utility to display Bluetooth transmitted data	9500.0029
BioHarness BT Config Tool	Utility to read device parameters and configure device mode	
IVT BlueSoleil v1.6.4.0 release 05920	Required for Bluetooth connectivity	
Windows ® Installer 3.1	Required for .NET installation	9500.0024
Microsoft ® .NET 3.5 Framework	Required for Zephyr Bluetooth Test App	9500.0023
Zephyr BioHarness Application	Utility to access data from BioHarness Device internal memory	9500.0021
Documents		
User Manual	This Manual	9700.0026
BioHarness Bluetooth API Guide	Guide to implementing an API	9700.0027
BioHarness Bluetooth Comms Link Specification		9700.0110
BioHarness Bluetooth Logging System Interface	File and data formatting for device internal memory	9700.0029

2. Setup

2.1. System Diagram



2.2. Overview

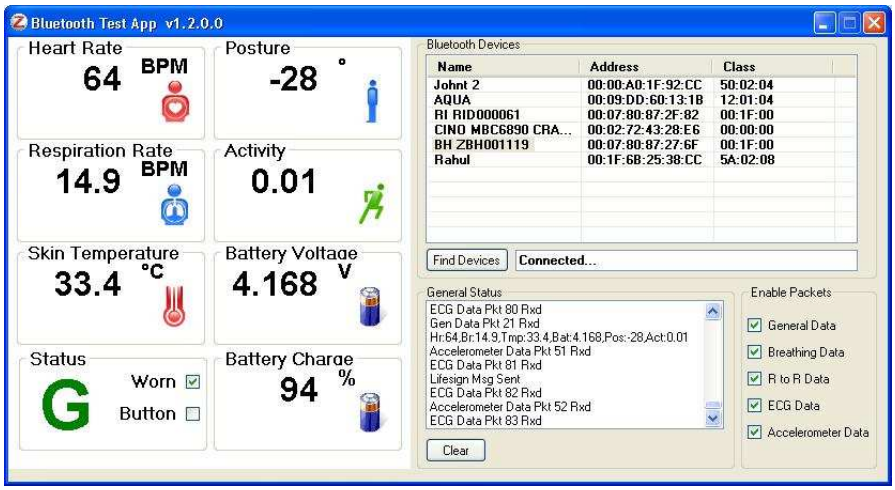
Do not connect the Bluetooth receiver or the BioHarness Device to a PC until the relevant driver software has been installed.

The following steps are recommended (in order) for setup and configuration of the system:

- Install Zephyr USB Driver software
- Connect BioHarness Device and cradle to PC for battery charge
- Install & Configure CNet Bluetooth Adapter Driver & IVT BlueSoleil software
- Install Microsoft ® .NET 3.5 Framework
- Copy Zephyr Bluetooth Test App
- Copy BioHarness BT Config Tool
- Install Zephyr BioHarness Application (only if recorded data import required)

2.3. Zephyr Software Utilities

2.3.1. Bluetooth Test Application



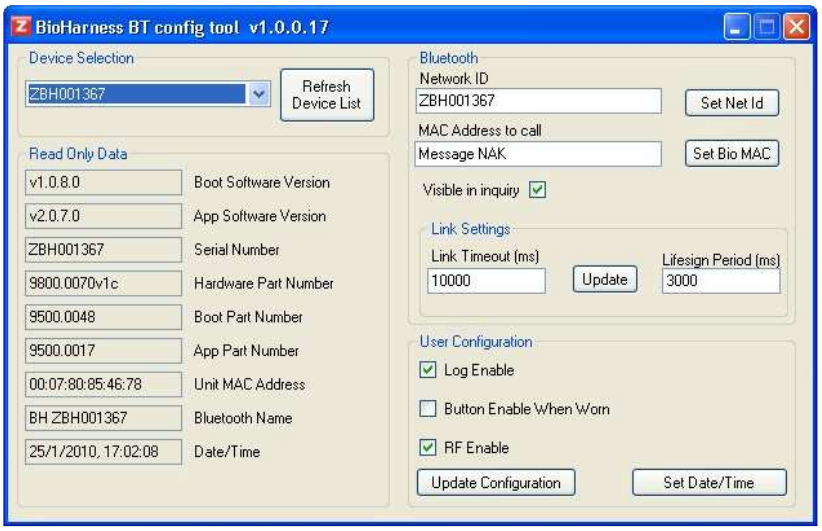
The Bluetooth Test App displays numerical values for the major transmitted data parameters as well as Bluetooth connectivity data. The Bluetooth Test App should be run in conjunction with the BlueSoleil Application supplied with the SDK; the Test App utilizes the BlueSoleil Driver files.

2.3.2. BioHarness Research Application

The BioHarness Application was originally designed for use with the 900MHz ISM BioHarness, but can also be used to import recorded data from the Bluetooth Device, export it to an external .csv file, and display a large number of parameters graphically.

The BioHarness Research application *cannot* be used to display live data. It can only be used to import logged data from the device which has been set to logging mode.

2.3.3. BioHarness BT Config Tool



This utility can be used to set a variety of parameters within the device:

Network ID:	Default device serial #
MAC Address to Call:	Hard code the MAC address of Bluetooth paired receiver
Visible in Inquiry:	Make device discoverable (default Yes)
Link Timeout:	Bluetooth link parameter
Lifesign Period:	Bluetooth link parameter
Log Enable:	Activate logging on button press
Button Enable When Worn:	Allow the device to be switched off while still attached to strap (default No – this prevents accidental switch off of device)
RF Enable:	Activate transmitting on button press
Set Date/Time:	Set internal clock to current PC time

2.4. Installation

Do not connect the BioHarness Device to a PC until the driver software has been installed

2.4.1. Zephyr USB Driver Install

1. Browse the Bluetooth Developer CD, and locate the ZephyrDeviceInstaller.exe file, in the Zephyr USB Driver folder.
2. Double-click the executable file to begin the installation process.
3. Follow the Wizard:

Click *Install*.

4. A dialogue will prompt to restart your PC to activate the changes.

Click ***Yes*** if you intend to connect any Zephyr hardware to the PC.

2.4.2. Zephyr Hardware Install

The BioHarness Device is powered by a Lithium Polymer cell which is charged via a PC USB Port. To install the hardware, simply connect to your PC in its charging cradle.

Two notification dialogues will display:

When the hardware is installed, the LED should illuminate as constant pale orange, to indicate the Device is charging.

If the LED is green, the device may have a completely discharged internal cell (insufficient to establish USB comms with the PC) – leave in the cradle for a few minutes, remove and replace. The LED should illuminate pale orange.

There is no charge state indication. 90% charge will be reached in hour from fully discharged. 100% is achieved in 3 hours. The charging automatically circuit prevents over-charging.

Constant pale orange LED indicates device is charging

2.4.3. Bluetooth Device Driver & Software Install

Note that the software should be installed prior to the USB Dongle being inserted into a USB port.

1. Insert the *IVT Bluetooth Driver and Software* CD which is included with the CNet USB Adapter Kit.

Installation should start automatically.

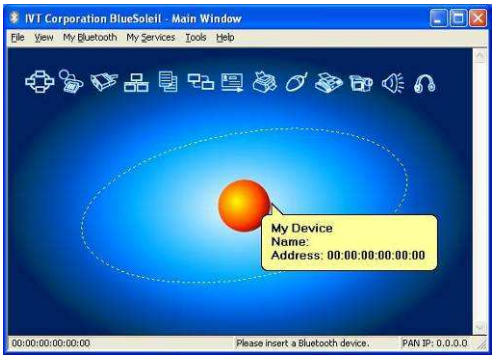
2. The BlueSoleil Application must be started before the Zephyr Bluetooth App.

Note that the Bluetooth Test Application is designed work with BlueSoleil v1.6.4.0 release 05920 (supplied with this SDK). It will not work with later versions of the BlueSoleil Application

3. *Windows Start>All Programs>IVT BlueSoleil*

…or in the System Notification tray on the bottom right of the Windows Toolbar, double-click on the Bluetooth icon.

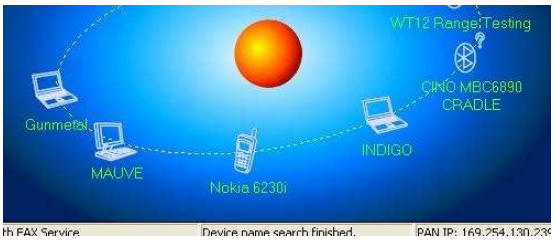
4. The main BlueSoleil window will be shown:



5. Insert the Bluetooth Adapter. A dialogue will display:

Enter Device Name and select Type – these labels will be used to identify your PC or laptop to any other Bluetooth devices in the vicinity.

To ensure the Bluetooth dongle is functioning correctly, double-click on the sun icon in the middle of the window. The display will change to identify all Bluetooth devices within range (this may take 30 seconds or so).



The Bluetooth comms are now fully functional.

2.4.4. .NET 3.5 Framework Install

The .NET 3.5 Framework is required for the Zephyr Bluetooth Test App to operate. As a pre-requisite, Windows ® Installer 3.1 must first be installed.

1. Browse the CD and locate the executable file *WindowsInstaller-KB893803-v2-x86.exe.* Double-click and follow the Wizard.

2. Browse the CD and locate the executable file *dotnetfx35.exe.* Double-click and follow the Wizard

2.4.5. Zephyr Bluetooth Test App Install

1. Browse the CD and locate the *Bluetooth Test App v1.2.0.0.exe* in the *Bluetooth Test Application/Application Release* Folder.
2. Copy this file to a suitable directory on your PC.

   Double-click on the executable itself to run the application – there is no Installer.

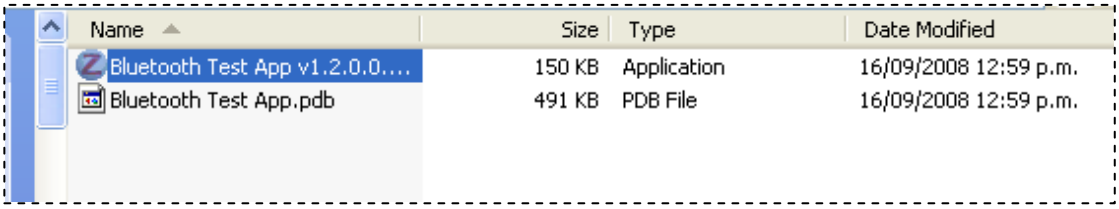
2.4.6. Zephyr BioHarness Application Install

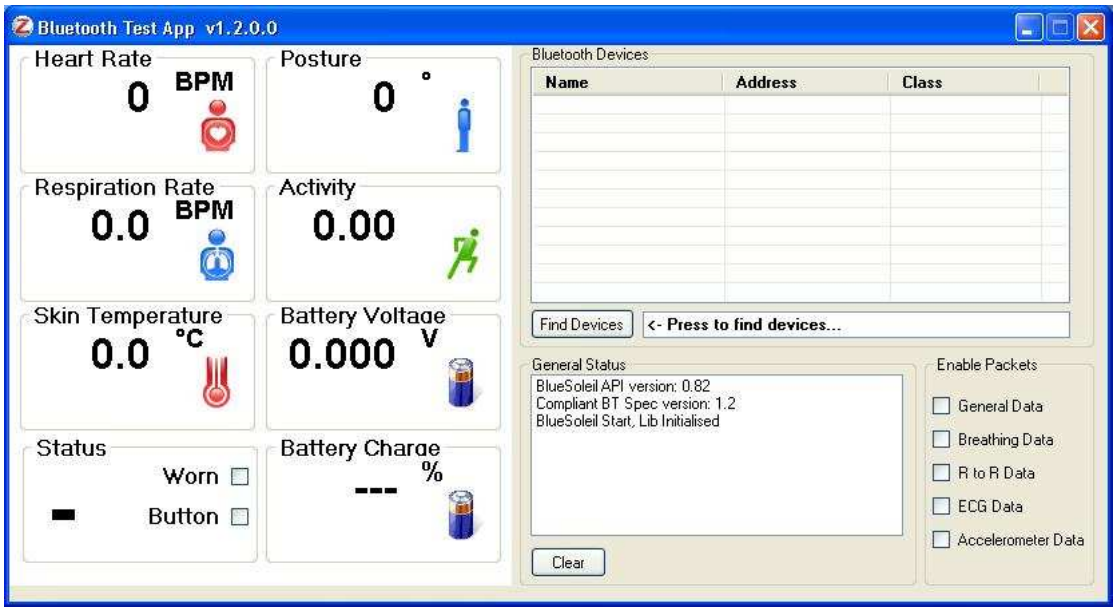
1. Browse the CD and locate the Bioharness_v2.3.0.7_setup.exe
2. Double-click and follow the Wizard to install this application.

3. Operation

3.1. Zephyr Bluetooth Test App

Once the PC application has been copied to a suitable folder on the PC with BlueSoleil running, double click on the executable:



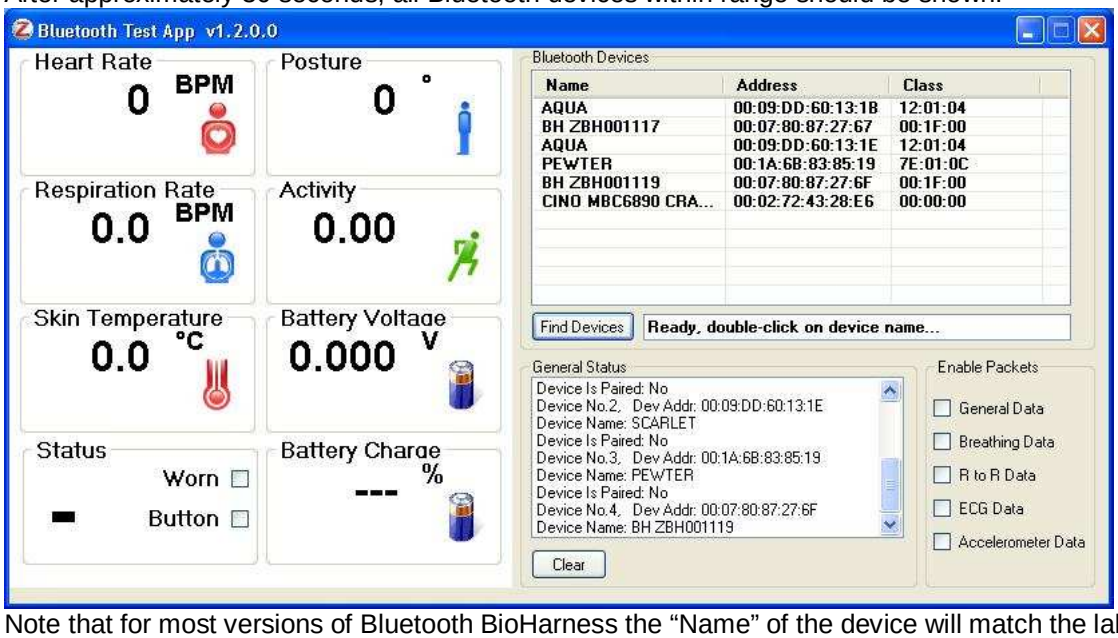


The PC application has 4 main GUI components:

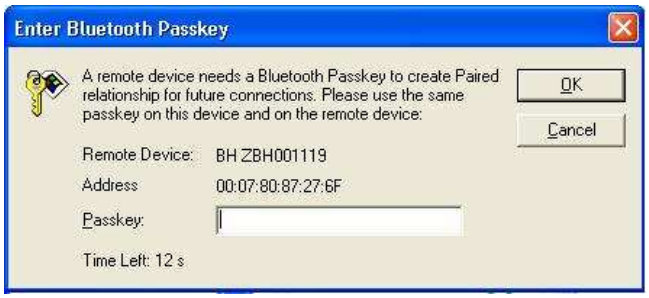
- Physiological and unit real-time update: provides display of the main values sent by the BioHarness on the left of the GUI e.g. Heart Rate, Battery Voltage. Whether garment is being worn, whether device button has been pressed. R/O/G subject status.
- Bluetooth Device List: When the “Find Devices” button is pressed, approximately 30 seconds later a list of all Bluetooth devices in range is populated.
- General Status: Gives general information on data received.
- Packet selection panel. A ticked box automatically enables the particular data packet to be transmitted. The data will be logged as csv files which are created automatically.

Double-click on the “Find Devices” button.

After approximately 30 seconds, all Bluetooth devices within range should be shown:

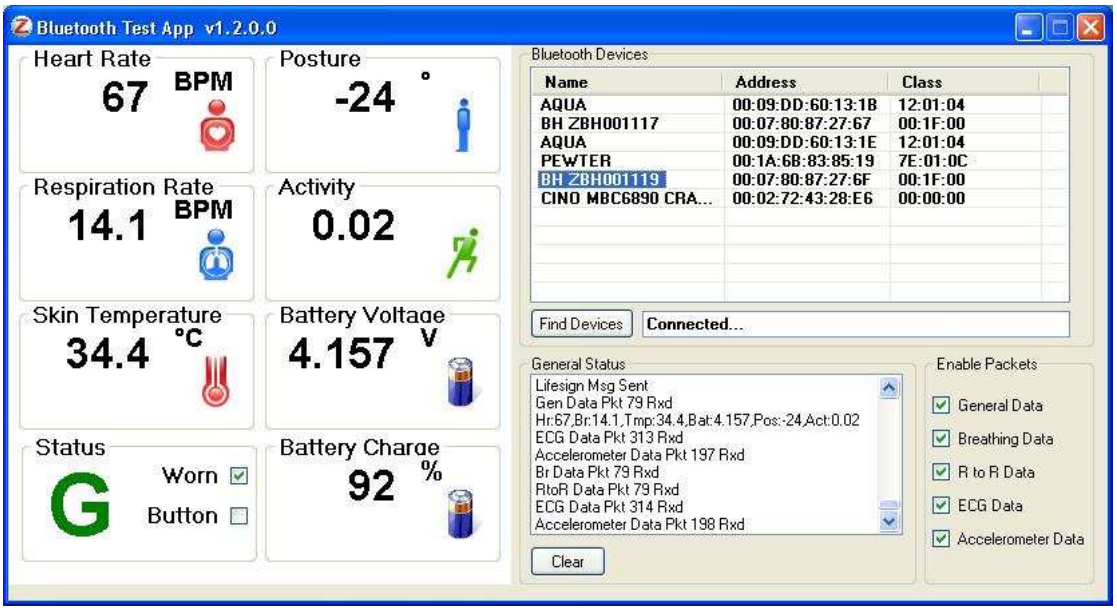


Note that for most versions of Bluetooth BioHarness the “Name” of the device will match the label on the back of the BioHarness.
In this example, we want to connect to the unit labeled “**BH ZBH001119**”. Double-click on the name:



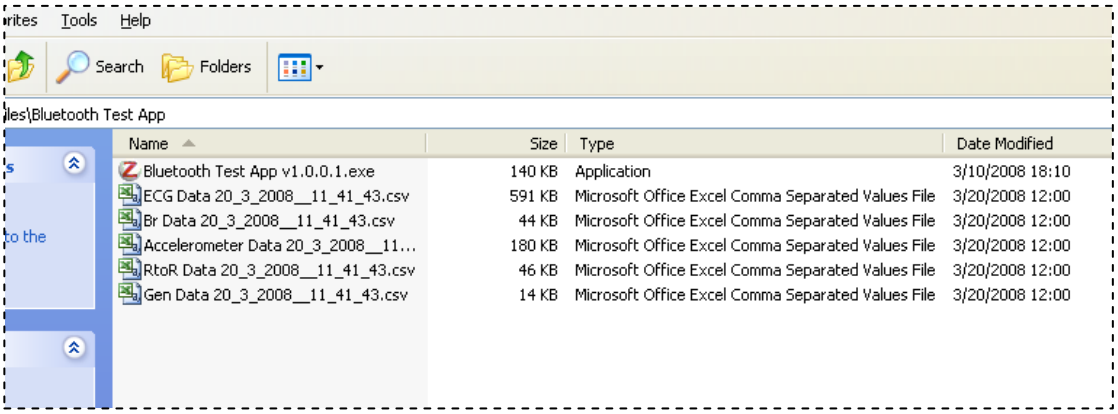
If a request for the Passkey/Pin Code is shown, enter “**1234**”.

The PC application should now start receiving data from the connected BioHarness:



While connected, the PC application writes all received data to .csv files in the same folder as the executable so the data can be retrieved later. The files can be accessed when the PC Application is closed using the “close” icon in the top right corner.

Close the GUI to stop communicating with the BioHarness and close the .csv files:



Note there are five files generated:

- Gen Data Packets: data with 1.008 second resolution e.g. Heart Rate, Battery Voltage.
- Br Data Packets: Breathing Waveform.
- R to R Data Packets: R to R data.
- ECG Data Packets: ECG waveform.
- Accelerometer Data Packets: X,Y & Z axis waveforms.

For more details on the data within each packet, see Section 4.

3.2. Zephyr BioHarness Application

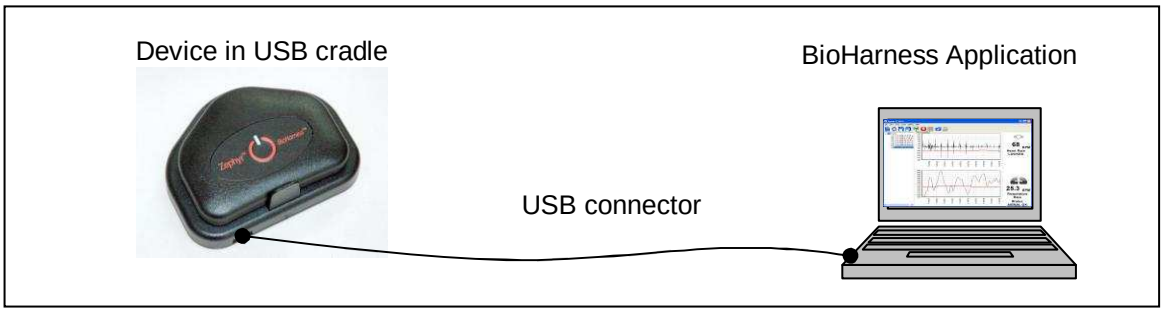
This application was developed for use in conjunction with the Zephyr BioHarness device which is configured to transmit in the 900MHz ISM frequency band – not the Bluetooth device. However, it *can* also be used as a utility to Import data recorded to the internal memory of a Bluetooth BioHarness device. *Some functionality, such as real-time data display, is not implemented for the Bluetooth Device*.

Note that before use the device must first be configured to logging mode – see page 6 for more information.

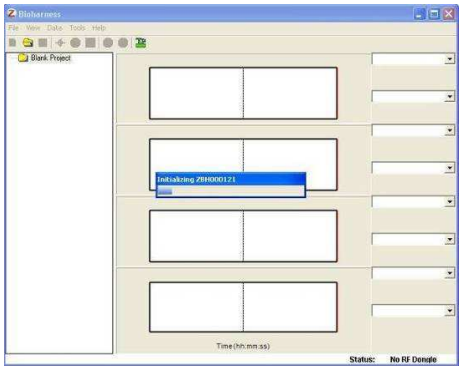
Imported log data can be viewed using the application, or exported to an external .csv file. The application will also initialize the internal RTC in the device, if it is inserted in its cradle when the application is open.

It is included in the Developer Kit as an aid to the development process, so that recorded data can be viewed at an early stage.

Connect the BioHarness Device to a PC using the cradle and connector provided. The LED should show pale orange, indicating battery charge.



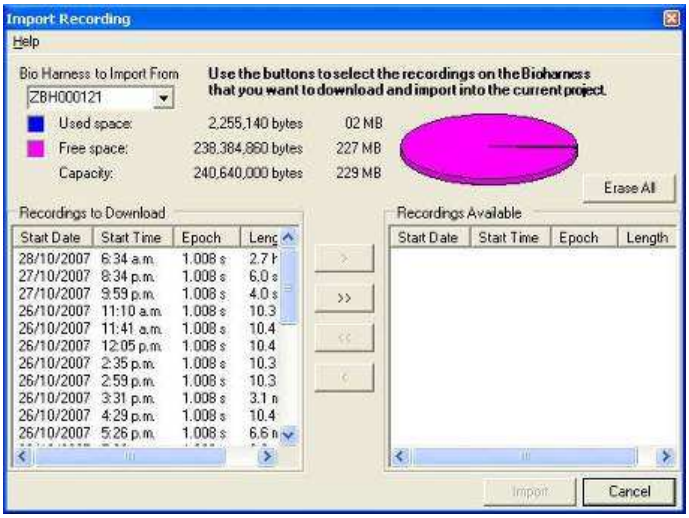
Use the Desktop Shortcut created by the installer, or ***Start>All Programs>BioHarness***



An '*Initializing*' dialogue will display. This resets the internal RTC in the device. This RTC is used to set timestamps transmitted in the General Data Packet as described in the *BioHarness Bluetooth Comms Link Specification* **[1].** The RTC assigns timestamps to the data as it is recorded into internal memory.

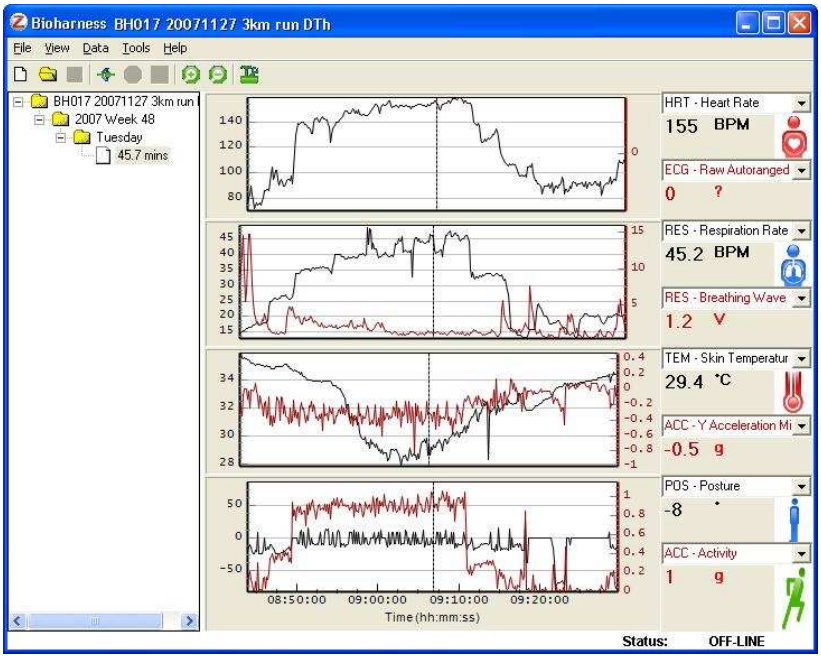
3.2.1. Importing Recorded Data

1. Connect device in cradle to PC and initialise as in previous section
2. Once the device has initialised, select the *File>Import* option from the application menu. A dialogue will display the recordings in the device memory.



3. Select the recording(s) required using the arrow selectors and click the *Import* button.
4. When import is complete, the recording(s) will show in the Explorer panel in the application.

3.2.2. Viewing Imported Data



Click on the session node in the Explorer tree to populate the graphs:

- The data values on the right reflect the position of the vertical dotted cursor.
- Left-click and drag the cursor to reposition it within the data set.
- Use mouse wheel or the zoom buttons on the application toolbar to zoom in on data around the cursor location.
- When zoomed in, the graphs can be panned left and right by left-click and drag with the mouse
- A variety of graph parameters can be viewed using the pull down lists on the right pane. Some of these paramters are generated by the BioHarness Application itself. The parameters logged by the device are described in Section 4.2.
- Use the *File>Save* and *File>Open* options in the application to save data as *.bioharness* files for subsequent viewing.
- Note that 250 Hz ECG data is not recorded by the device – this data can be viewed in the ECG data .csv files created by the Bluetooth App.

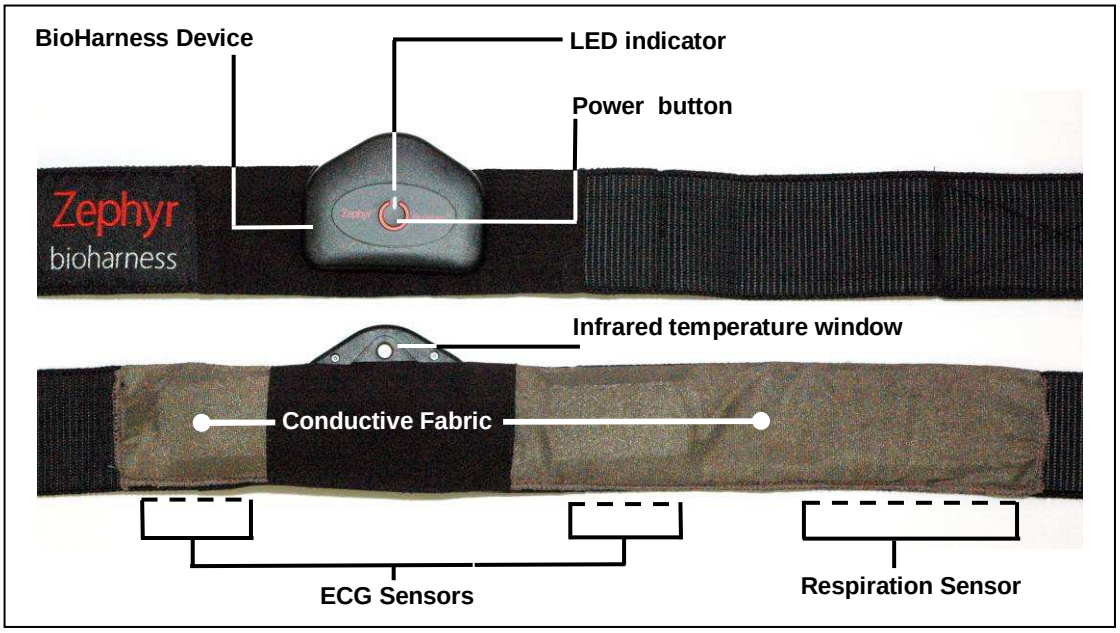
3.2.3. Exporting Data to an External File

A number of data export options are accessible by right-clicking a session and selecting from the context menu.

Contact Zephyr support if more information is required on the nature of the data recorded.

3.3. BioHarness Device and Strap

3.3.1. Components



The power button switches the device on and off. The device will then transmit data or log it internally, or transmit and log simultaneously, according to how it has been configured.

Device configuration cab be done using the BioHarness BT Config Tool supplied with this SDK, or using the appropriate messages described in the [1] *BioHarness Bluetooth Comms Link Specification*.

Device configuration is indicated by the LED behavior described in the next section.

3.3.2. LED Behaviour

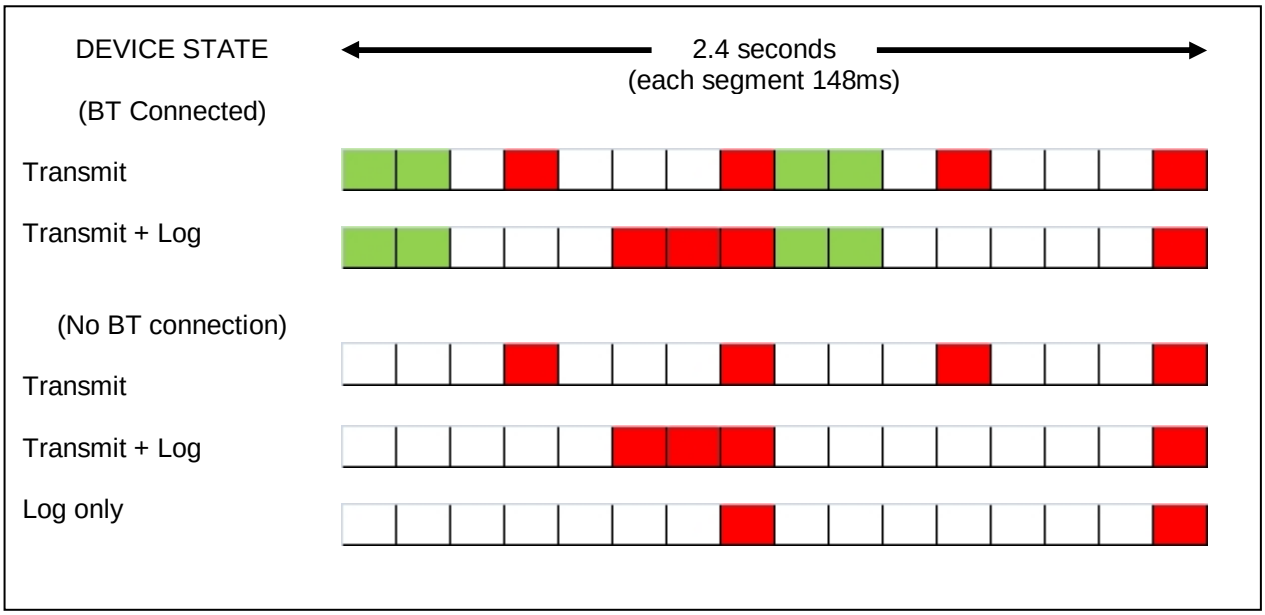
The BioHarness module can operate in three modes:

- Transmit data by Bluetooth
- Log data to internal memory (no transmit)
- Both Transmit and log the same data simultaneously

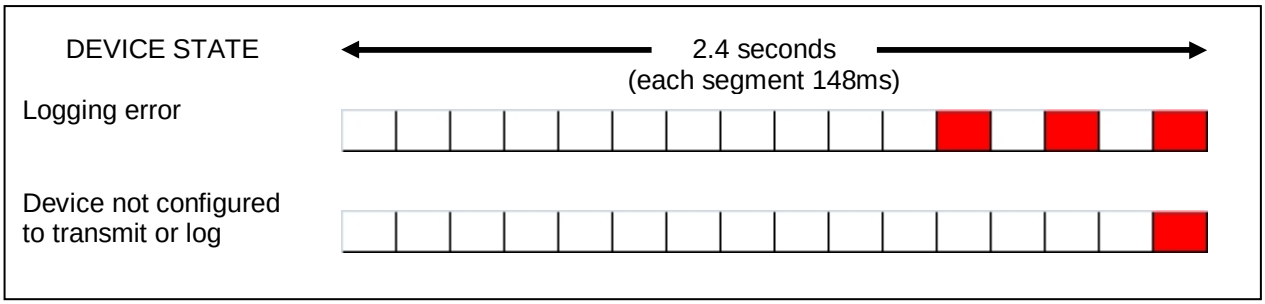
The device can be configured to these modes using the BT Config Tool. A flashing RED LED will indicate which of the above modes the device is in.

A BioHarness can transmit data, but it must have also established a Bluetooth connection with a Bluetooth receiving device before data can be relayed to any application software. A device may transmit data – and indicate it is doing so by red LED flash – even although it is not connected to a receiving device..

A flashing GREEN LED will indicate that this connection is present.



3.3.3. LED Error States



3.4. Care & Maintenance

3.4.1. BioHarness Device:

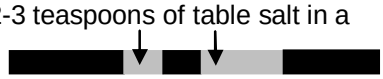
- O-ring sealed and water resistant.
- Wipe with a soft damp cloth and towel-dry
- Clean the Temperature window with a cotton bud
- Do not leave in direct sunlight for long periods (such as in a vehicle)

3.4.2. BioHarness Strap:

- Detach the BioHarness Device
- Rinse the garment in fresh water after use to disperse the salt from perspiration.
- Hand wash, or machine wash on a Cold, Delicate setting after 30 days of use.
- Firmly attach the Velcro ® fastenings together and do not wash with other delicate garments which may be damaged by these fastenings. Use a washing pouch if possible.
- Do not spin or tumble dry
- Hang to dry, out of direct sunlight
- Do not use bleach
- Do not iron

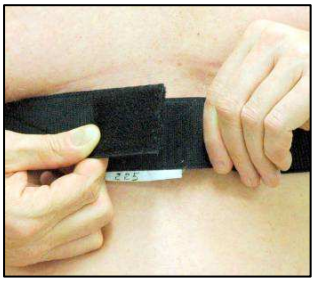
3.5. Strap Fitting & Location

- Lightly moisten the ECG sensor pads for best performance. Don't use distilled water.Tap water should be adequate, but an electrolyte solution of 2-3 teaspoons of table salt in a litre of water is ideal.

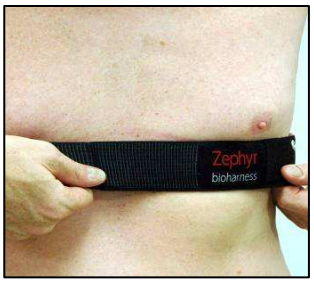


The ECG will work when dry, but be more susceptible to signal noise when the wearer is very active.

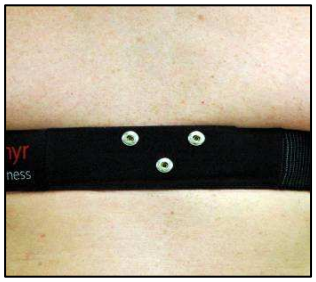
- Put the garment on backwards first, for easier adjustment of tension and alignment of the Velcro ® fastening
- Adjust the tension so that the garment is snug but comfortable and will not move under expected activity



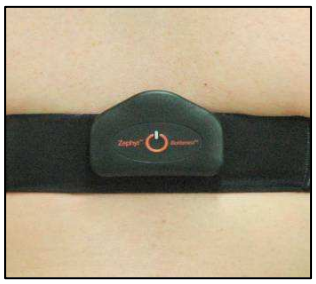
- Position the garment so that is just below the chest muscles



- Rotate the garment to that the fasteners are centred on the torso, with middle snap above the sternum



- Attach the BioHarness device, set to transmit or recording mode as necessary



4. Data Descriptions

4.1. Transmitted Data

Data output from the device is described fully in the *BioHarness Bluetooth Comms Link Specification [*1]. Data output is in the form of a number of messages, each of which can be enabled or disabled. Details on how to do this are included in the above document.

Parameter	Reporting Frequency (Hz)	Range	Units	Description
General Data Packet				
Heart Rate	1	0 – 240	BPM	Beats per Minute
Breathing Rate	1	0 – 70	BPM	Breaths per Minute
Skin Temperature	1	0 – 60	℃	
Posture	1	±180	Degrees	Vertical = 0°
Activity Level	1	±3.3	VMU (g)	
Peak Acceleration	1	±3.3	g	
Battery Voltage	1	3.5 – 4.2	V	
Breathing Wave Amplitude	1		V	Indicative only
ECG Amplitude	1		V	Indicative only
ECG Noise	1		V	Indicative only
X Acceleration Min	1	±3.3	g	Vertical axis
X Acceleration Peak	1	±3.3	g	
Y Acceleration Min	1	±3.3	g	Lateral axis
Y Acceleration Peak	1	±3.3	g	
Z Acceleration Min	1	±3.3	g	Sagittal axis
Z Acceleration Peak	1	±3.3	g	
ROG Status	1	R,O,G		See section 5
Strap Worn Status	1	0,1		0 = not worn.
Device Button pressed status	1	0,1		0 = not pressed
Battery Percentage of Full Charge	1	0 – 100	%	% of full capacity
Breathing Data Packet				
Breathing sensor output	18	0 – 4095	bits	Does not indicate breathing depth
ECG Packet				
ECG Sensor output	250	0 – 1024	bits	For debugging purposes only
Heart Rate R-R Packet				
HR RR value	18	Minimum 250	ms	Alternating ± sign at new detection
Accelerometer Data packet				
X axis acceleration	50	±3.3	g	
Y axis acceleration	50	±3.3	g	
Z axis acceleration	50	±3.3	g	

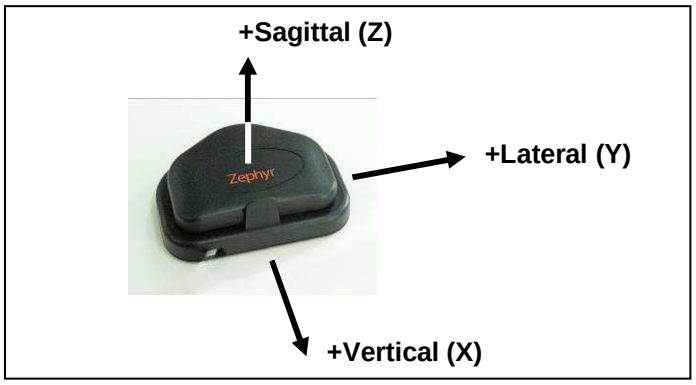
All data packets are time-stamped in milliseconds

4.2. Logged Data

Log data descriptions are fully described in the *BioHarness Bluetooth Logging System Interface [3]*

Parameter	Reporting Frequency (Hz)	Range	Units	Description
Heart Rate	1	0 – 240	BPM	
Breathing Rate	1	0 – 70	BPM	
Skin Temperature	1	10 – 60	℃	
Posture	1	±180	Degrees	Vertical = 0°
Vector Magnitude	1	±3.3	VMU(g)	
Peak Acceleration	1	±5.7	g	
Battery Voltage	1	3.5 – 4.2	V	
Breathing Wave Amp	1		V	Indicative
ECG Amplitude	1		V	Indicative
ECG Noise	1		V	Indicative
X Acceleration Min	1	±3.3	g	
X Acceleration Peak	1	±3.3	g	
Y Acceleration Min	1	±3.3	g	
Y Acceleration Peak	1	±3.3	g	
Z Acceleration Min	1	±3.3	g	
Z Acceleration Peak	1	±3.3	g	
Breathing Sensor output	18	0 - 4095	bits	
HR RR Value	18		ms	Alternating ± sign on new detection
Skin Conductance Level	1		nS	Indicative

Orientation of Vertical/Lateral/Sagittal axes for acceleration data – the arrows show the direction for positive data values:



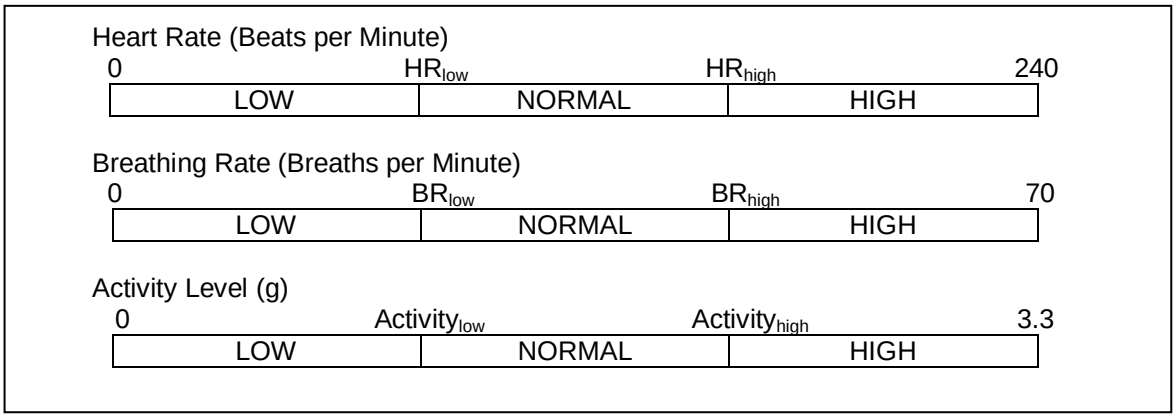
5. ROG Subject Status Indication

The BioHarness module outputs a subject status indication which has the values:

- Green – subject's physiological parameters are within thresholds as configured
- Orange – one or more of the subject's parameters have crossed the configured threshold values. The subject's data should be monitored more closely.
- Red – one or more of the subject's parameters have exceeded threshold values for a sustained period (configurable). The subject's physiological parameters should be monitored closely, and confirmation sought if there is an indication of stress, fatigue or trauma.

5.1. ROG Threshold and Alert State Logic

Subject Status is determined by analyzing Heart Rate, Breathing Rate and Activity level values, calculated over a 5 second rolling average. Activity level is measured by an accelerometer within the BioHarness Device. Parameters are determined to be LOW or HIGH according to the following thresholds:



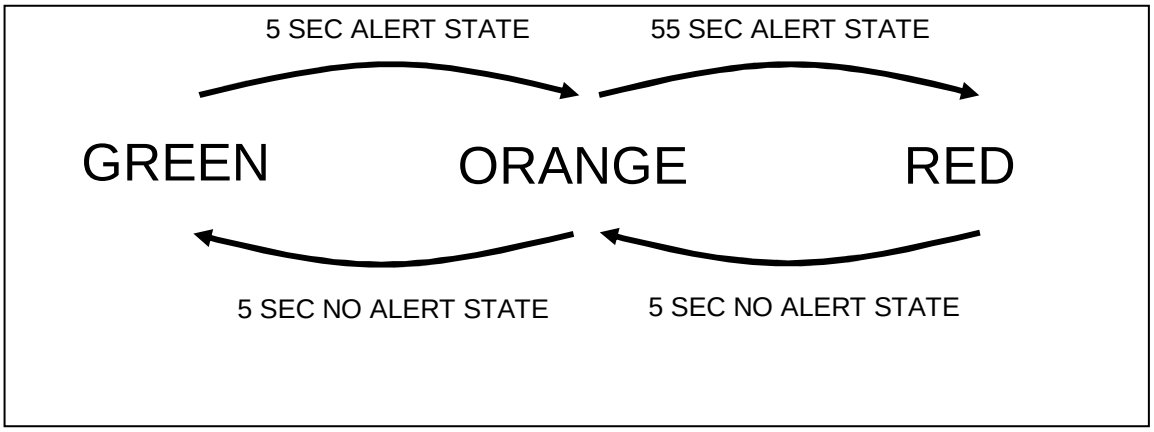
If any of the subject's parameter's above cross from the NORMAL zone to LOW or HIGH values, the subject's state may be raised from Normal to Alert, according to the logic table below. Any other states are Normal. Each line in the table represents one permutation of parameters which generate an Alert state

Heart Rate	Breathing Rate	Activity Level	State
NORMAL	NORMAL	NORMAL	No Alert
LOW			Alert
	LOW		Alert
HIGH		NOT HIGH	Alert
	HIGH	NOT HIGH	Alert

The following logic is then applied:

Status Green	+	Alert for 5 seconds	=	Status Orange
Status Orange	+	Alert for 55 seconds	=	Status Red
Status Red	+	No Alert for 5 seconds	=	Status Orange
Status Orange	+	No Alert for 5 seconds	=	Status Green

A No Alert State for 5 seconds will reduce State from Red to Orange, or Orange to Green.



The time intervals shown above are also configurable. The values indicated are the default values:

Green + 5 seconds Alert = Orange > Green to Orange Time
Orange + 55 seconds Alert = Red > Orange to Red Time.

5.2. ROG Default Values

Subject ROG thresholds can be configured and stored inside the device, so that it can transmit an indication of ROG status as determined by the logic in the previous sections. Information on configuring the device ROG thresholds is described for developers in [1] *BioHarness Bluetooth Comms Link Specification*.

The default values for these thresholds are:

Threshold	HR Low	HR High	BR Low	BR High	Activity Low	Activity High	Green to Orange Alert transition time	Orange to Red Alert Transition Time
Default	40	160	4	30	0.2	1.0	5	55
Units	Beats per Min.	Beats per Min.	Breaths per Min.	Breaths per Min.	VMU (g)	VMU (g)	Seconds	Seconds

6. Device Worn detection

The BioHarness BT has worn detection circuitry. If the device detects insufficient resistance across the uppermost pair of snaps, then it can respond to a request and send a 'Not Worn' indication. See the *BioHarness Bluetooth Comms Link Specification* document for details on the message and response to determine this.

Using this information, it is possible to configure the device to NOT respond to a button press on the front of the device if it detects it is being worn. This is to prevent accidental powering off of the device in the field.

If this setting is enabled, then the device must be removed from its strap before being powered off. Care must be taken to avoid contacting both upper snaps simultaneously with fingers as you grasp the device to power off, as the resistance detected may prevent device power-off.

The device may not detect it is being worn if there is a poor conductive path while it is actually being worn. This is typically caused by insufficient moisture, either in the sensor pads, or on the subject's skin. Moisten the sensor pads with water if this is observed.

The device may also detect it is worn when the strap is not on a subject, if there is sufficient moisture within the strap itself to create a conductive path – i.e. if the strap itself is saturated. Users should be aware of this possibility.

Issue	Solution
Any problem establishing Bluetooth connectivity or loss of Bluetooth transmitted data	Uninstall and re-install the BlueSoleil Bluetooth drivers. Check BlueSoleil version; Test App will not work with later versions than that supplied.
Worn checkbox in BT Test App not checked when device worn; no Breathing or HR data.	Poor skin conductivity - Moisten sensor pads with water

Please contact support@zephyr-technology.com if you have any issues you cannot resolve.