

# Zephyr™ Performance Systems

## BioPatch HP User Guide



**Medtronic**

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2016-NOV-29	Initial release

This manual describes the operation, function and specifications of the BioPatch™ for Human Performance Monitoring Device manufactured by Zephyr™ Technology Corp, a part of Medtronic.

It is available online from:

*[www.zephyranywhere.com/resources/documentation](http://www.zephyranywhere.com/resources/documentation)*

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### Glossary

AT	Anaerobic Threshold – closely associated with 2 <sup>nd</sup> ventilatory threshold
BLE	Bluetooth Low Energy / Bluetooth Smart / Bluetooth 4.0
BPM	Beats per minute (Heart rate) or Breaths per minute (Breathing rate)
BR	Breathing Rate = Respiratory Rate
BT	Bluetooth®, Bluetooth 2.1
ECG /EKG	IN the context of this product, the term ECG is used to describe a non-clinical cardiac rhythm waveform
ECHO	2.4 GHz 802.15.4 Zephyr radio network used by PSM Training
Epoch	A period between two reporting intervals – nominally 1 sec duration for physiological data. E.g. Peak/Min value of all samples during that 1 second interval.
Gateway	ECHO Receiver device connected to PC
GPS	Global Positioning System
HP	(BioPatch HP) for Human Performance
HR	Heart Rate
HR max	Maximum heart rate of an individual subject
HRV	Heart Rate Variability
LED	Light Emitting Diode
KML	Keyhole Markup Language – Google Earth file format
PC	Personal Computer
PSM	Physiological Status Monitoring [system]
RH	Relative Humidity
ROG	Red / Orange / Green[ subject physiological status indication]
USB	Universal Serial Bus – PC hardware connection
VMU	Velocity Magnitude Unit – a measure of activity level (in g) over a fixed time interval

### References

The following documents are referred to in the contents:

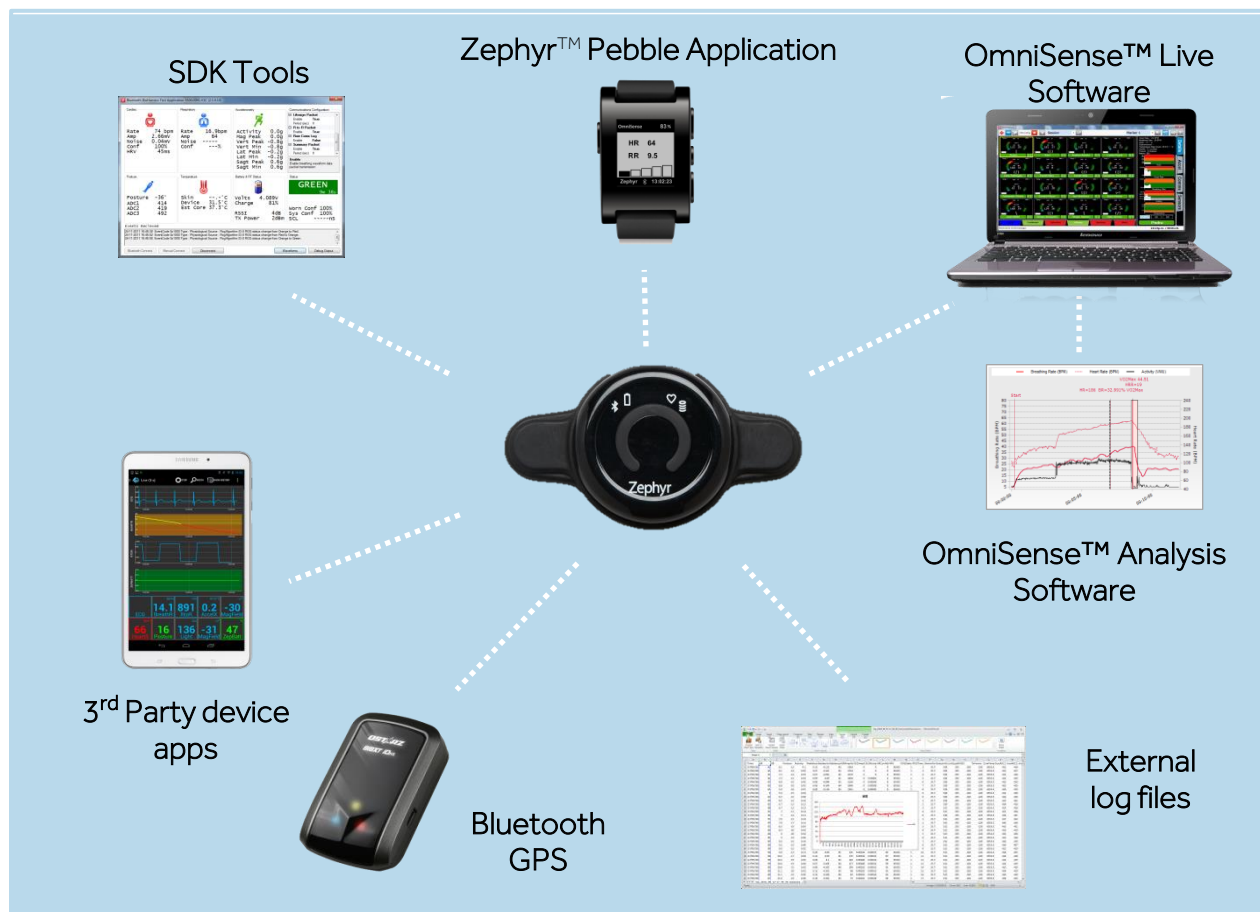
[1]	BioModule™ Data Sheet
[2]	BioModule™ Log Descriptions
[3]	PSM Training User Manual
[4]	BioModule™ Bluetooth SDK User Manual

### Introduction

### Cautions

- ◆ Stop use of the device if the subject experiences discomfort or skin irritation.
- ◆ Breathing rate values are accurately transmitted when sedentary e.g. seated and not speaking.
- ◆ If no breathing rate is reported within 2 minutes, alternate methods should be considered. Other physiological parameters may continue to function.
- ◆ If the subject has arrhythmia heart rate may be inaccurate.
- ◆ This device does not provide ECG analysis other than heart rate.
- ◆ Do not wear in explosive atmospheres
- ◆ Do not wear near blasting areas where radio detonation methods may be used
- ◆ Charging at high temperatures (> 45°C / 113°F) has risk of fire or explosion
- ◆ Do not dispose of in a fire
- ◆ Should not be used for swimming or water-based activities
- ◆ No user-serviceable components
- ◆ Warranty void if opened
- ◆ This product is not intended for medical use.

### Overview



The BioPatch™ HP monitoring device can transmit live physiological data, or download log data to a variety of platforms:

- |                                                                                                                              |                                                                                                                                                                                                                                   |
|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• ECHO</li> <li>• Bluetooth</li> <li>• Bluetooth Low Energy</li> <li>• USB</li> </ul> | <p>OmniSense™ Live (Zephyr PSM Training) Software</p> <p>SDK Tools &amp; 3<sup>rd</sup> Party Device Applications</p> <p>Zephyr™ Pebble Application</p> <p>OmniSense™ Analysis Software, Log Downloader to external log files</p> |
|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Data waveforms are available for ECG, breathing sensor output and raw 3-axis accelerometry.

Data is simultaneously logged in the BioModule™ and can be imported into appropriate software for viewing, or exported to external data files. A variety of log formats are available.

If used in conjunction with a supported GPS device, the BioModule™ can also log geolocation, speed and altitude data.

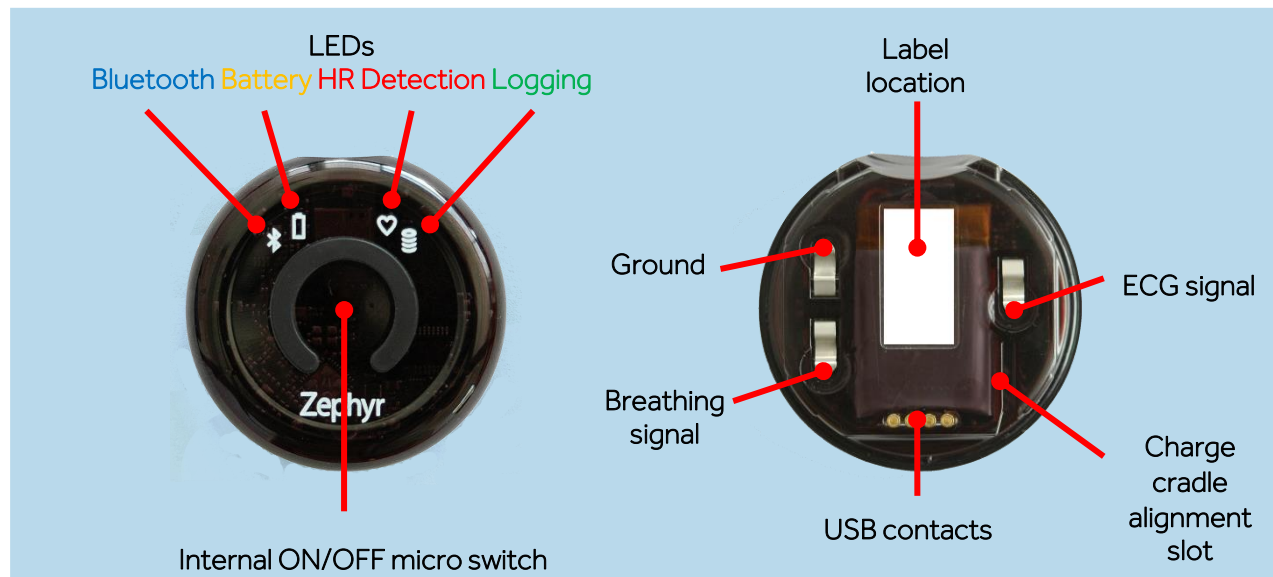
### Components



BioModule™ and the black holder can be cleaned and used for multiple subjects  
 Electrodes (not pictured): single use only

Electrode recommendation:

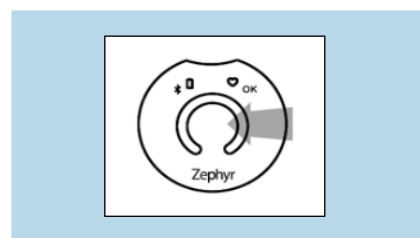
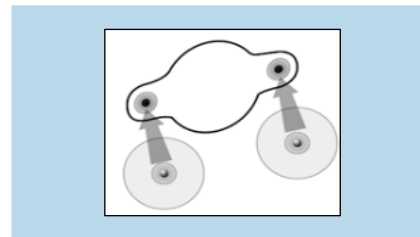
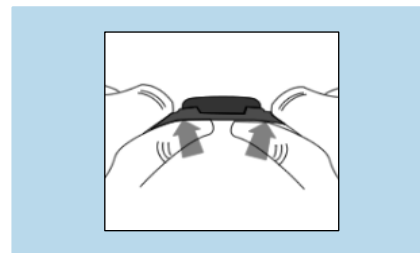
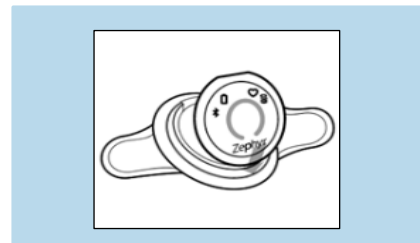
- Compatible for use on self-adhesive electrodes with 3.5mm male snap interface.
- Best performance with foam or cloth electrodes of conductive solid hydrogel variety depending on application.
- For heavy perspiration, cloth electrodes will provide superior adherence.





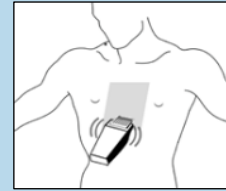
### Prepare BioModule™ for Use

- a) Obtain your charged BioModule™ from the charging cradle
- b) Clean BioModule™ using instructions found in this guide
- c) Snap the BioModule™ into the BioModule™ holder (larger notch in the upper rim). BioModule 'Zephyr' logo at the bottom of the holder.
- d) To remove, press the BioModule™ holder from the rear as shown.
- e) Verify that the electrode expiration date has not passed and the gel is moist. Keep the electrode package in a zip top bag after opening to keep electrodes moist.
- f) Snap two electrodes to the holder. It is ready to apply.
- g) Press and hold the device center firmly to turn it on. The red light will light up and the blue light will flash.
- h) To turn off, press center and hold till all LEDs illuminate and the device powers off.

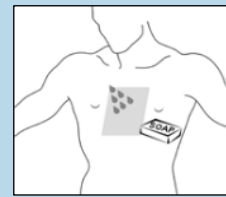


### Skin Preparation

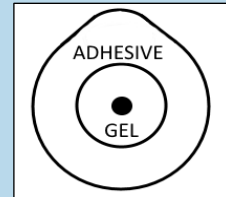
- a) Select the area to prepare as indicated in the figure.
- b) Clip hair to make sure electrodes adhere to the skin.



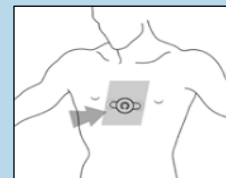
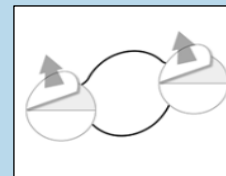
- c) Wash skin with soap and water to remove dirt, lotions and dry skin cells. Rinse well.
- d) Dry the area with a cloth to remove any hair or soap.



- e) Peel the backing from the electrodes.

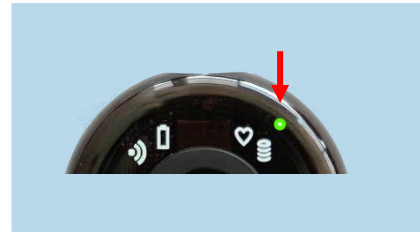


- f) Apply firmly in line with the breast bone as shown, just below the sternal notch.

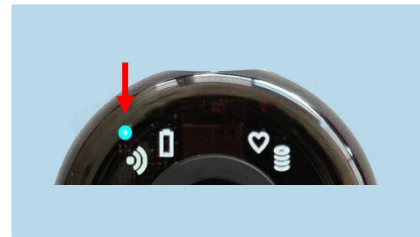


### BioModule™ Light Indicators

- a) **GREEN:** flashing – working normally. Data is being logged.



- b) **BLUE:** flashing – data is being transmitted, by Bluetooth or ECHO.



- c) **ORANGE:** Constant – less than 30% battery. Off – less than 10% battery. Recharge in cradle. Flashing – working normally.



- d) **RED:** constant – No heart rate detected. Check electrode connection. Off – heart rate detected. Flashing – working normally.



- e) In Charging Cradle:

- f) Flashing Orange = Charging (1 hr to 90%)  
 g) Constant Orange = Charged (3 hrs to 100%)  
 Ready to use.



### Care & Maintenance

- Electrodes may be disposed in general home waste.



- The BioModule™ & Black Holder are reusable and should be surface cleaned with detergent and warm water.



- For maximum battery life, keep the BioModule™ 50% – 90% charged – i.e. charge for an hour after use.
- Recharge once per month if left for long periods of time.
- The BioModule™ cannot be accidentally over-charged.



### Transmitted Data

The following parameters are transmitted in versions of the Summary Data Packet.  
Reporting Rate: 1 Hz

Parameter	Range/Units	Description
Heart Rate	0 – 240 beats/minute	N/A
Breathing Rate	0 – 70 breaths/minute	N/A
Posture	-180 – 180 degrees from vertical	0° = vertical, + = lean forward
Activity Level	0 – 16 g reported as VMU	0.2 VMU ~ walking, 0.8 ~ running
Peak Acceleration	0 – 16 g	Any axis, previous second epoch
Battery Level	~3.5 – 4.2 Volts	3.5V ~ 0%, 4.2V ~ 100%
Breathing Wave Amplitude	Bits	Not used
ECG Amplitude	mV	N/A
ECG Noise	mV	N/A
HR Confidence	0 – 100%	Valid if > 20%, multiple components
Heart Rate Variability	milliseconds	300 beat SDNN
ROG Status	R, O, G	Used in OmniSense
Status Info	Decimal >> Binary	Multiple Internal Status Flags
Link Quality	0 - 254	Bluetooth Link Quality. 0 = poor.
RSSI	-127 – 127dB	Received Signal Strength Indication
Tx Power	-30 – 20 dBm	Bluetooth Transmit power
Estimated Core Temperature	Degrees	HR Based
GPS Position	Lat/Long	With supported GPS
GPS Speed	Miles/hour	With supported GPS
Impulse Load	Newtons - cumulative	Measure of mechanical Load
Walk Step Count	Count	N/A
Run Step Count	Count	N/A
Bound Count	Count	N/A
Jump Count	Count	N/A
Minor Impact Count	Count	Impact > 3g
Major Impact Count	Count	Impact > 7g
Average Rate Force Development	Newtons per second	Measure of explosive power
Average Step Impulse	Newton Seconds	Meaure of energy expended
Average Step Period	Seconds	Time duration of step
Jump Flight Time	Seconds	Duration of jump event
Peak g Phi Angle	0 – 180 degrees (0 = vertical)	Vertical direction of peak impact
Peak g Theta angle	-180 – 180 degrees (0 = forward)	Horizontal direction of peak impact

A variety of other data packets may be enabled, including:

Data Packet	Reporting Frequency	Description
Breathing Waveform	18 Hz	Raw sensor output
ECG Waveform	250 Hz	Processed output
Accelerometer Waveform	50 Hz	X/Y/Z accelerometer data
RR Interval	Per Event	RR intervals in milliseconds
BB Interval	Per event	Breath-breaths intervals in milliseconds

For more information refer to the *BioModule Data Sheet* [1]

### Logged Data

The following parameters are contained in the Enhanced Summary Log format.

Reporting Rate: 1 Hz

Parameter	Range/Units	Description
Heart Rate	0 – 240 beats/minute	N/A
Breathing Rate	0 – 70 breaths/minute	N/A
Posture	-180 – 180 degrees from vertical	0° = vertical, + = lean forward
Activity Level	0 – 16 g reported as VMU	0.2 VMU ~ walking, 0.8 ~ running
Peak Acceleration	0 – 16 g	Any axis, previous second epoch
Battery Voltage	~3.5 – 4.2 Volts	3.5V ~ 0%, 4.2V ~ 100%
Battery %	0 – 100%	N/A
Breathing Wave Amplitude	Bits	Not used
ECG Amplitude	mV	N/A
ECG Noise	mV	N/A
HR Confidence	0 – 100%	Valid if > 20%, multiple components
Heart Rate Variability	milliseconds	300 beat SDNN
System Confidence	0 – 100%	N/A
GSR Status	Not used	N/A
ROG Time	Seconds	Time in current ROG status
ROG	Red, Orange, Green	Subject status reported in OmniSense™/PSM Training
Vertical Acc'n Min.	-16 – 16 g, in previous epoch	Vertical axis
Vertical Acc'n Peak	-16 – 16 g, in previous epoch	N/A
Lateral Acc'n Min.	-16 – 16 g, in previous epoch	Side-side axis
Lateral Acc'n Peak	-16 – 16 g, in previous epoch	N/A
Sagittal Acc'n Min.	-16 – 16 g, in previous epoch	Front-rear axis
Sagittal Acc'n Peak	-16 – 16 g, in previous epoch	N/A
Status Info	Decimal >> Binary	Multiple Internal Status Flags
Link Quality	0 - 254	Bluetooth Link Quality. 0 = poor.
RSSI	-127 – 127dB	Received Signal Strength Indication
Tx Power	-30 – 20 dBm	Bluetooth Transmit power
Estimated Core Temperature	Degrees	Based on Heart Rate
Aux ADC 1/2/3	Not used	N/A
Impulse Load	Newtons - cumulative	Measure of mechanical Load
Walk Step Count	Count	N/A
Run Step Count	Count	N/A
Bound Count	Count	N/A
Jump Count	Count	N/A
Minor Impact Count	Count	Impact between 3g and 7g
Major Impact Count	Count	Impact > 7g
Average Rate Force Development	Newtons per second	Measure of explosive power
Average Step Impulse	Newton Seconds	Meaure of energy expended
Average Step Period	Seconds	Time duration of step
Jump Flight Time	Seconds	Duration of jump event
Peak g Phi Angle	0 – 180 degrees (0 = vertical)	Vertical direction of peak impact
Peak g Theta angle	-180 – 180 degrees (0 = forward)	Horizontal direction of peak impact

For more information refer to the *BioModule™ Log Descriptions* document [2]

### Log Formats

A number of logging formats are available. They can be configured using the Zephyr™ Config Tool. When downloaded to external files, a single log format may generate multiple files, of different reporting rates.

Format	Description
General	1 Hz physiological & accelerometer + 18 Hz breathing sensor output & Heart RR
General & ECG	General + 250 Hz ECG
General & Accelerometer	General + 100 Hz Accelerometer magnitude
Summary	1 Hz physiological, accelerometer, confidence & status + Heart RR intervals + Breath BB intervals
Summary & Waveform	Summary + 250 Hz ECG waveform + 100 Hz 3-axis Acceleration magnitude + 25Hz breathing sensor output
Summary & Development	Summary + 1KHz ECG waveform + 50 Hz 3-axis Acceleration magnitude + 25Hz breathing sensor output
Enhanced Summary	Summary + additional impact analysis values
Enhanced Summary & Waveform	Enhanced Summary + 250 Hz ECG waveform + 100 Hz 3-axis Acceleration magnitude + 25Hz breathing sensor output
Enhanced Summary & Development	Enhanced Summary + 1KHz ECG waveform + 50 Hz 3-axis Acceleration magnitude + 25Hz breathing sensor output

If a supported GPS device is used, the BioModule™ must be configured to Summary & Waveform or Enhanced Summary & Waveform, to support GPS data in the log. An additional kml log file will be generated by the Log Downloader tool.

For more detailed descriptions, see the *BioModule™ Log Descriptions [2]* document.

Enhanced Log formats are supported from BioModule firmware versions 1.5.0.0 and onwards, which support OmniSense 4.0 and onwards.

### Log Download Times for 1 hr Log

Log download times vary according to the software used, and the log format. OmniSense™ Analysis provides the fastest download time options.

(Enhanced) Summary Log Format	OmniSense 3.9.7 (Summary)	OmniSense 4.1 (Enhanced)
1 BioModule	1 min	12 sec
10 BioModules		50 sec
50 BioModules		6 minutes

(Enhanced) Summary & Waveform Log Format	OmniSense 3.9.7 (Summary)	OmniSense 4.1 (Enhanced)
1 BioModule	5.5 min	45 sec
10 BioModules		95 sec
50 BioModules		9 minutes

Downloading log data using the BioHarness™ Log Downloader tool will take longer than the above times.



### Software

#### USB Drivers

Before connecting a BioModule™ by USB to a PC to configure it, update firmware or download log files. USB Drivers must be installed.

Device drivers are installed automatically when OmniSense™ is installed as part of a Zephyr™ (PSM Training) system installation. In all other cases, USB drivers must be installed manually. No drivers are needed if you only need to charge the device.

The USB Driver installer can be downloaded from the Zephyr™ website at:

<https://www.zephyranywhere.com/resources/software-download>

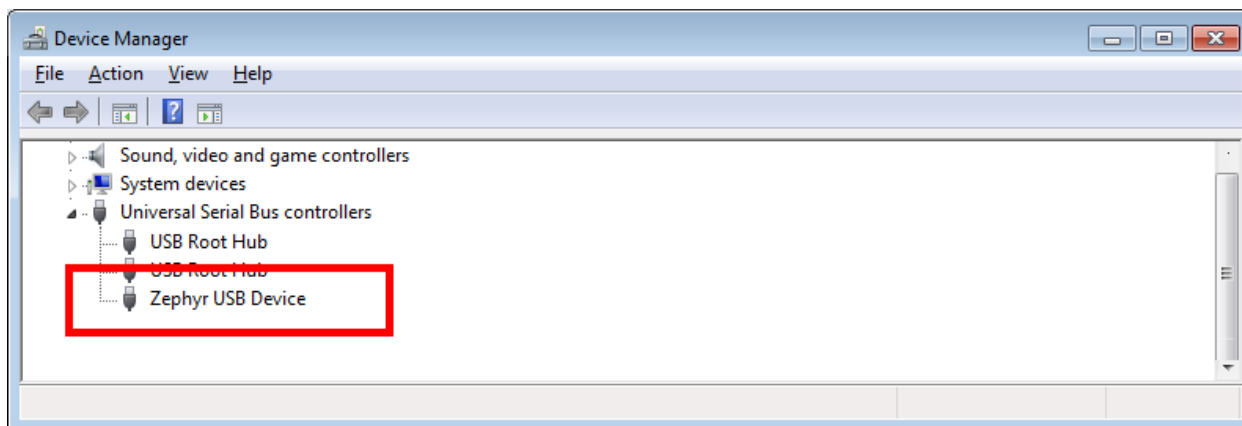
The link is at the foot of the page.

**ZEPHYR USB DEVICE DRIVER FOR BIOMODULE™ DEVICE (BIOHARNESS™ DEVICE) 3.0**

Please follow the instructions for installation that are included with the driver.

[DOWNLOAD NOW](#)

Download and unzip the Driver file *bioharness-3-win-usb-driver.zip* and run the *BH3DriverInstaller.msi* installer file. Full instructions are included in the download.



When installed, the BioModule™ will display in Windows® Device Manager as a *Zephyr USB Device*.

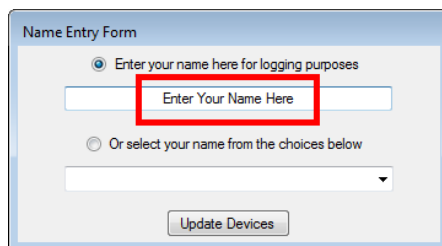
### Zephyr™ Config Tool

The Zephyr™ Config Tool can change a variety of settings in the BioModule™ and other Zephyr™ devices. Change *only* those settings as advised in Zephyr™ documentation. Note any changes you make, so they can be reverted if necessary.

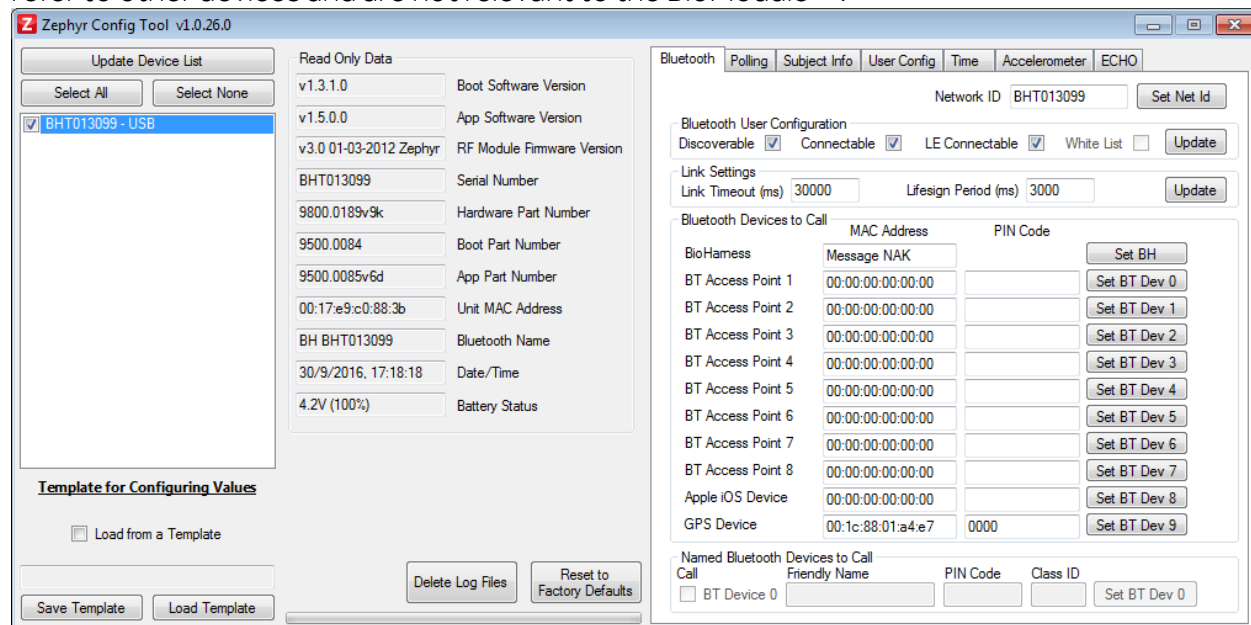
The Config Tool is a component of the Bluetooth SDK, and is included with a PSM Training OmniSense™ install. It can be requested from the Zephyr™ website at:

<https://www.zephyranywhere.com/resources/developer-user-tools>

When the *Zephyr™ Config Tool.exe* is run, a dialogue will display. Enter your name to start the tool. The tool keeps a log of any changes made to devices at C:\ProgramData\Zephyr\ZephyrDeviceUpdateLog.csv.

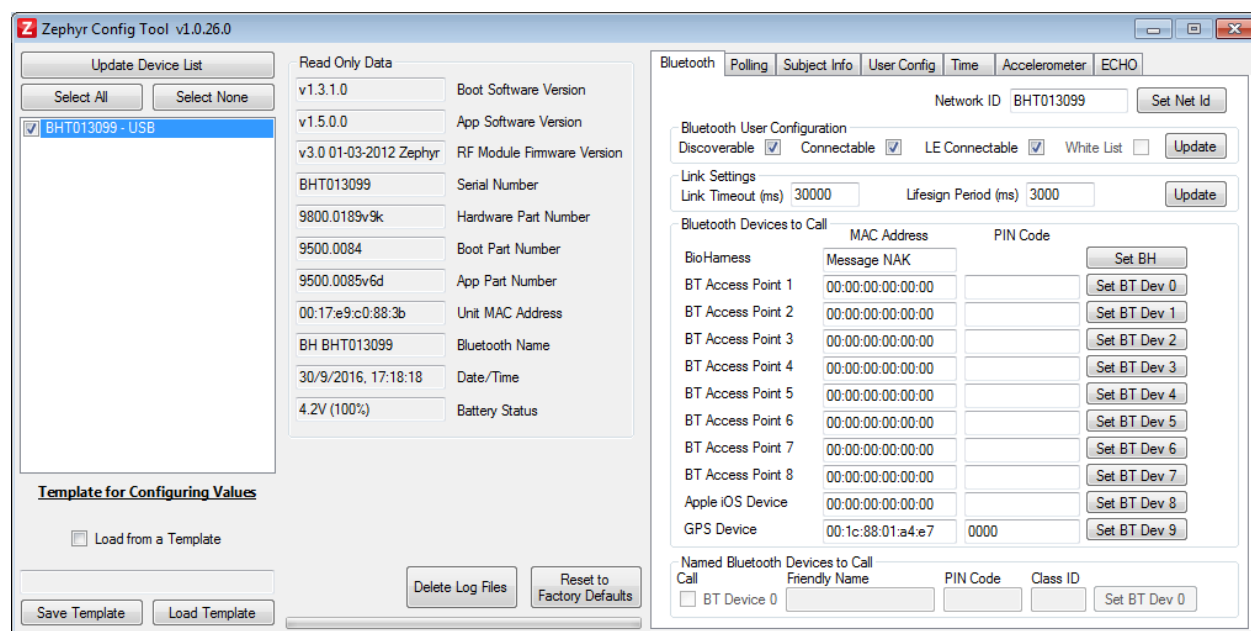


The tool has multiple tabs to configure various aspects of the BioModule™. Many settings refer to other devices and are not relevant to the BioModule™.



Check the box adjacent to your BioModule™ to read the device and populate the fields.

## General/Bluetooth Tabs



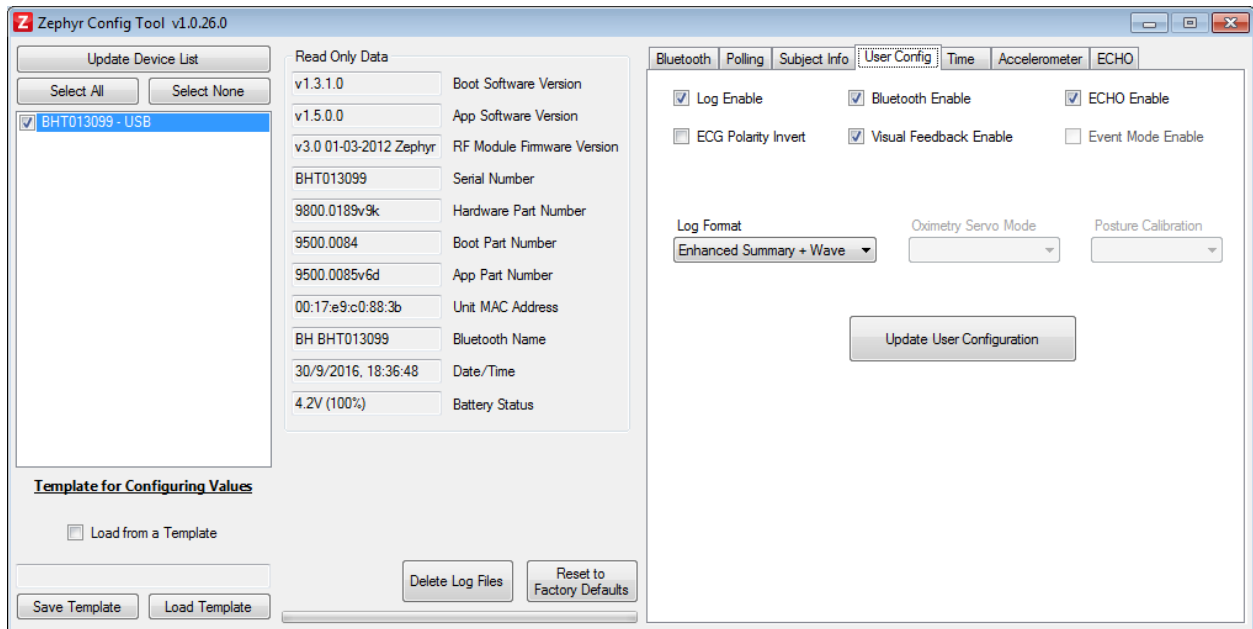
### Read-Only Data

App Software Version	The device firmware version (v1.5.0.0 above, may vary)
Hardware Part Number	Will identify your generation of BioModule™ (.v9k above = _3G)
Delete Log Files	Will <i>permanently</i> delete all logs from the device
Reset to Factory Defaults	Do not use unless advised by Zephyr™ Support

### Bluetooth

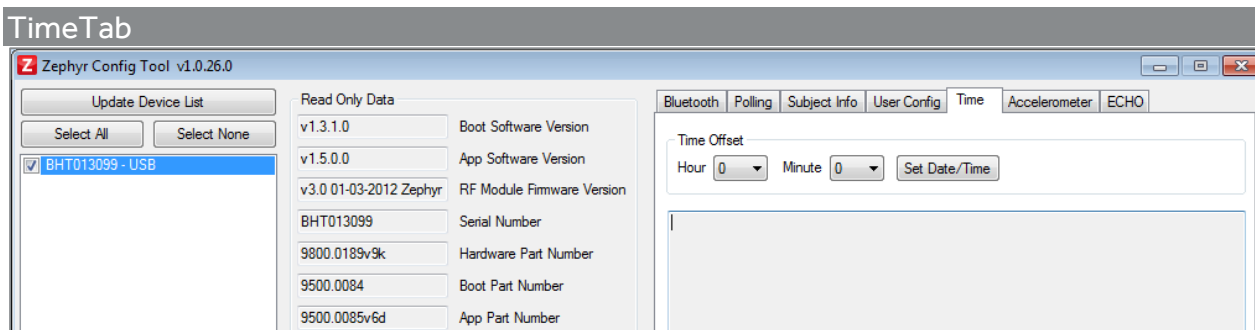
Network ID	Name which will be detected on Bluetooth devices
Discoverable	Leave checked
Connectable	Leave Checked
LE Connectable	Leave checked (Bluetooth Low Energy)
GPS Device	Add GPS Mac address manually. OmniSense™ will do this over-the-air
Other settings	Do not change

## User Config Tab



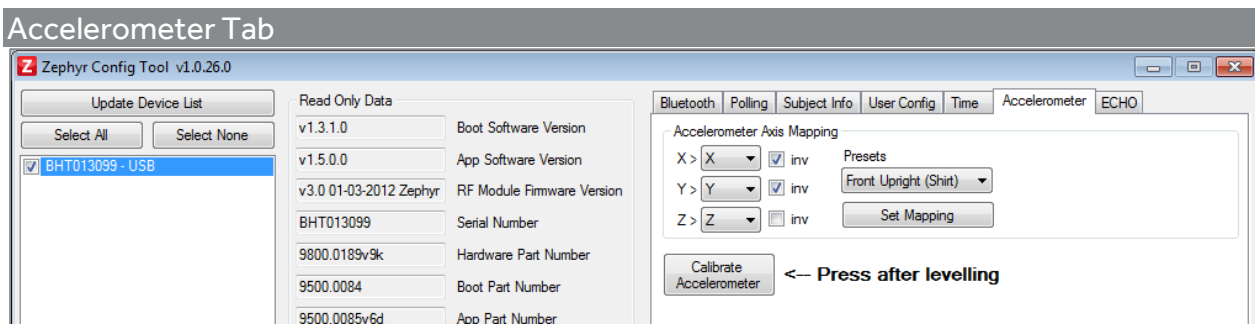
Log Enable	Log data internally
Bluetooth Enable	Enable BT 2.1 & BT 4.0
ECHO Enable	Enable ECHO
Visual Feedback Enable	Enable LEDs
Log Format	Set logging format
Update User Configuration	Use the button to update any changed settings

Logging formats are described in the parameters section.



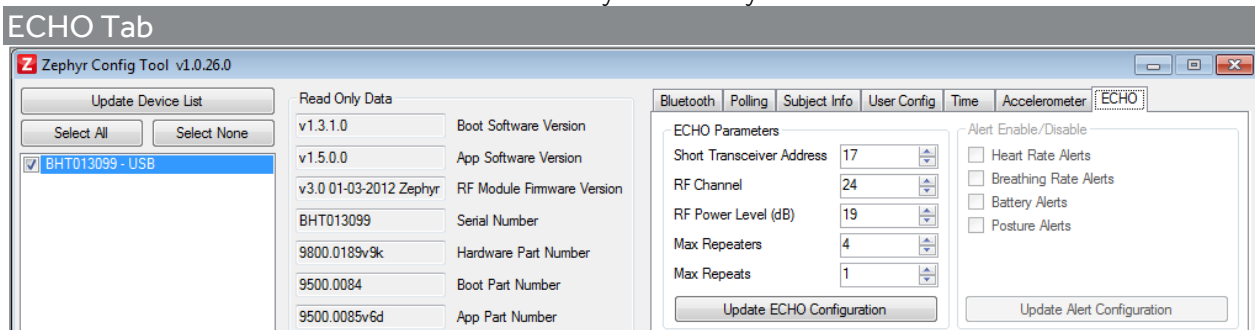
Set Date/Time to synchronize device clock with PC time. This happens automatically whenever logs are downloaded from the device.

For optimal time accuracy, set device time before use if no logs have been recently downloaded.



Presets should be *Front Upright (Shirt)* for BioPatch™ HP use. This sets the correct accelerometer axis mapping.

*Calibrate Accelerometer* – this should *not* be needed. The device must be in the charge cradle on a calibrated horizontal surface if absolutely necessary.



Settings relevant for use with OmniSense™ Live software.

Omitted tabs refer to settings for non-BioModule™ devices.

### Zephyr™ USB Updater

Zephyr™ issues periodic firmware updates for BioModules™. There will be several versions for each firmware revision, and versions for various applications of the BioModule™.

Care must be taken to identify that you have the correct firmware version for your device and should not be changed without consulting a product specialist.

The Updater tool is included in the SDK, and installed as part of OmniSense™ software. Firmware image files are of the type \*.img and are labelled with the version number, and BioModule™ generation number e.g. v1.5.0.201\_3G. (1.5.0.0 pictured below)

All factory-supplied BioPatch™ HP monitoring devices are \_3G devices.



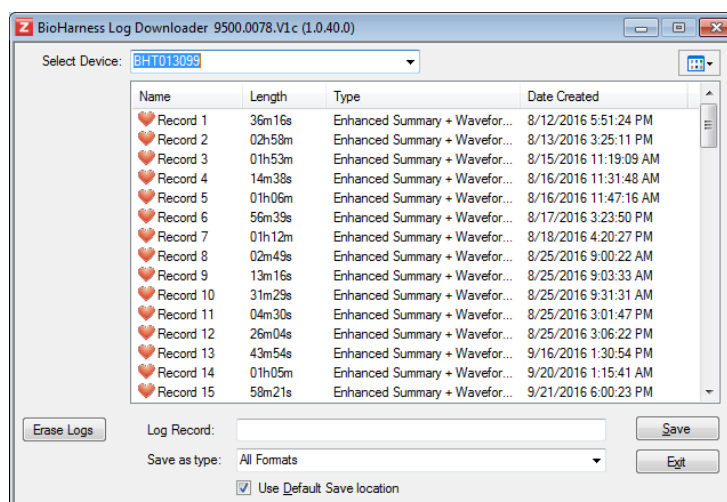
- Connect BioModule™ to PC in charge/USB cradle
- Open *ZUSBUpdater.exe* and browse for the firmware image file
- Check box at right for your device(s)
- Select *Start!*. Red and green LEDs will flash while device updates
- Retry the process if it fails

### BioModule™ (BioHarness) Log Downloader

The Log Downloader can be used to download log files from the BioModule™ and generate external files of the type .csv (which will open in Microsoft® Excel or Notepad applications).

The Log Downloader tool is included in the SDK, and installed as part of OmniSense™ software. It can also be downloaded from the Zephyr™ website at:

<https://www.zephyranywhere.com/resources/developer-user-tools>



- Connect BioModule™ to PC in USB/charge cradle
- Open *BioHarness Log Downloader.exe*
- Select Device from pulldown
- Save As Type - Select a log for download by selecting the Record field from the list

Log Enable	CSV Format – files will open in Excel/Notepad DaDISP Format - .hed/.dat file pairs for import to DaDISP®
Use Default Save Location	Default is <i>..My Documents/BioHarness Test Logs</i> unless unchecked, then save where appropriate.

### BioModule™(BioHarness) Bluetooth Low Energy (BTLE) SDK

Intended for developers, the kit is available for purchase from:

<https://www.zephyranywhere.com/resources/developer-user-tools>

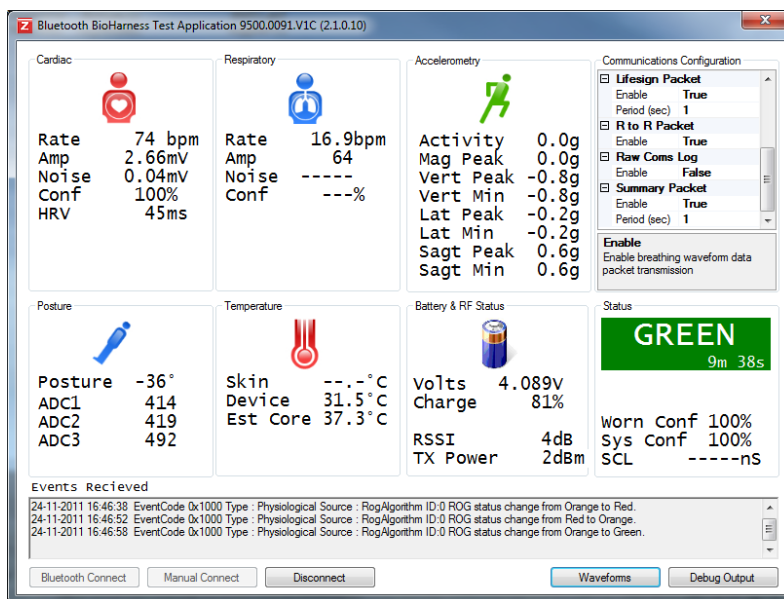
The kit contains documentation describing

- All Bluetooth data packets and log formats
- All Serial Port communication and configuration messages over USB or Bluetooth

In addition, the tools

- USB Driver files
- ZUSBUpdater
- Zephyr™ Config Tool
- BioHarness Log Downloader
- Bluetooth Test Application
- Sample Android Project

The Bluetooth Test Application can display streaming data from the BioModule™:



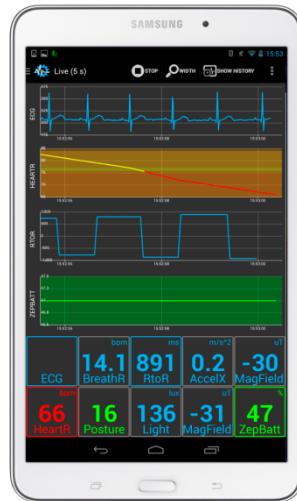
Note that the Developer Kit does not support ECHO communications. It contains no source code, .dlls or an API which would accelerate the development process.

For more information refer to the *BioModule™ Bluetooth SDK User Manual* [4]



### 3<sup>rd</sup> Party Device Applications

A number of 3<sup>rd</sup> party applications for Android phones & tablets are available commercially. Check with the app developers that your preferred app specifically supports the Zephyr™ BioModule.



When troubleshooting issues with these applications, contact the app developer rather than Zephyr™ Technology.

### Zephyr™ Pebble Application



- Watch supports BioModule™ with Bluetooth Low Energy
- Zephyr™ Watch App is preloaded when the watch is shipped
- Three customizable fields on screen
- Heart Rate, Respiration Rate, Training Zone, Estimated Core Temperature, Posture, Activity Level, Heart Rate Variability (after 300 beats), Stress Level (1 – 10)
- Update rate 1 / 5 / 10 / 15 / 20 / 25 / 30 / 35 / 40 / 45 / 50 / 55 / 60 seconds

The watch, with proprietary Zephyr™ firmware and Zephyr™ Watch App pre-installed, can be purchased from our online store at

[www.zephyranywhere.com/online-store](http://www.zephyranywhere.com/online-store)

## OmniSense™ Software

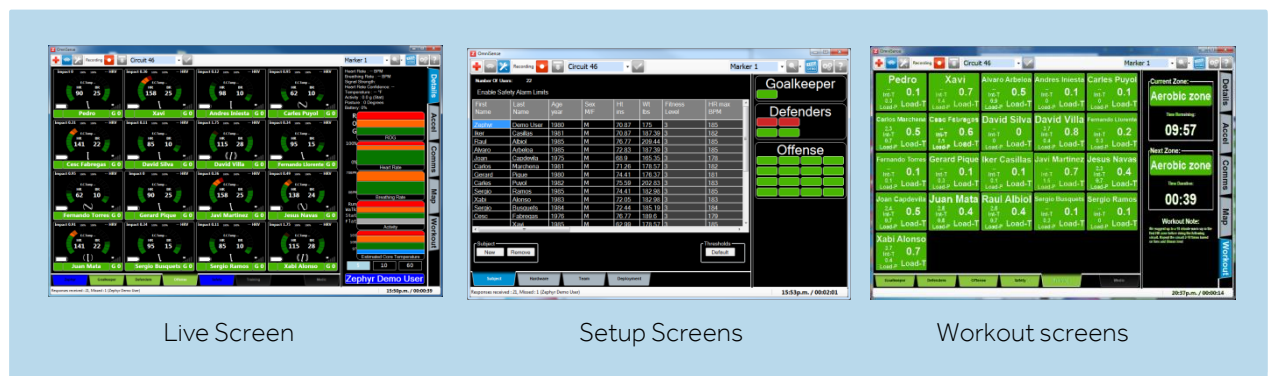
OmniSense™ Software is the Zephyr™ application intended for use with the PSM Training system. It supports up to 100 BioModules over the ECHO radio protocol.

A 30 day free trial of version 3.9.7 of the software can be downloaded from the Zephyr™ website at:

<https://www.zephyranywhere.com/resources/software-download>

The application consists of two modules, OmniSense™ Live software and OmniSense™ Analysis software, and a number of utilities.

## OmniSense™ Live Software

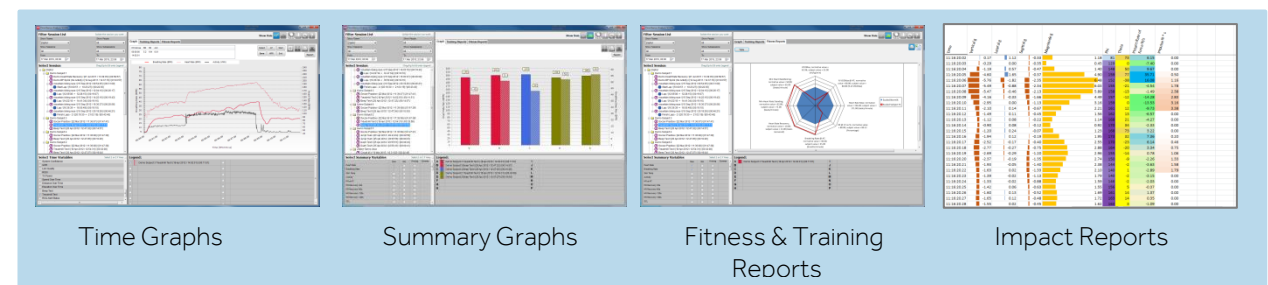


Live Screen

Setup Screens

Workout screens

## OmniSense™ Analysis Software



Time Graphs

Summary Graphs

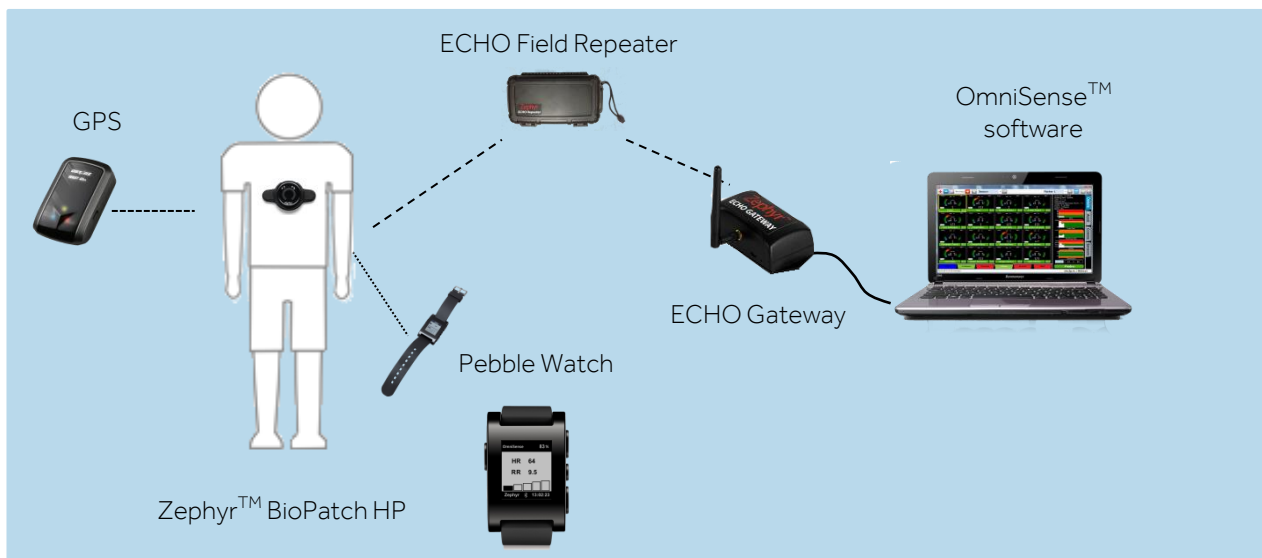
Fitness & Training Reports

Impact Reports

OmniSense™ software must be used in conjunction with an ECHO Gateway receiver and optional repeater stations in the field.

For more detail information, refer to the *PSM Training User Manual* [3]

### The Zephyr™ System (PSM Training System)



- Remote relay of multiple physiological parameters, including
  - Heart Rate
  - Breathing Rate
  - Activity Level
  - Estimated Core Temperature
  - Subject Orientation
- OmniSense™ Live software streaming data display
- Visual sweep scale and color-coded display, fully configurable
- Red/Orange/Green subject status algorithms
- Full data recording and display using OmniSense™ Analysis
- Fitness and Training Reports

- Support of up to 100 subjects
- Range of up to 600 yards with optional field repeaters
- Optional GPS Speed & Distance, and Map display with supported Bluetooth GPS
- Optional individual feedback using Pebble Watch
- Optional additional sensors for Blood Pressure & Oxygen Saturation
- Fitness Testing
- Workouts
- Record all data on the BioModule™ and import into the database

### OmniSense™ Live & Analysis Software Parameters

Parameter	Units	Description
Heart Rate	Beats/minute	N/A
Breathing Rate	Breaths/minute	N/A
Heart Rate Variability	Milliseconds	After 300 beats
Estimated Core Temperature	Degrees F/C	HR based
Impact	g	N/A
Activity Level	VMU	Walk ~ 0.2 VMU, Run ~ 0.8 VMU
Calories	kCal	Heart Rate based calculation
% Maximum Heart Rate	%	Maximum as saved from Fitness tests
% Heart Rate at AT	%	HR @ AT as saved from Fitness Tests
Physical Intensity	0 – 10 scale	Based on Heart Rate
Mechanical Intensity	0 – 10 scale	Based on Accelerometry
Training Intensity	0 – 10 scale	Average of Phys + Mech
Physical Load	Accumulating Index	Accumulation of Phys. Intensity
Mechanical Load	Accumulating Index	Accumulation of Mech. Intensity
Training Load	Accumulating Index	Accumulation of Training Intensity
Jump Force	g	Static Jump. Specific criteria.
Explosiveness	g	From 40 yard dash test. Specific criteria.
Stress Level	0 – 10 scale	Calculated from HRV.
Saturated Blood Oxygen	%	Additional sensor required
Blood Pressure	mmHg	Additional sensor required
Speed	Miles Per Hour	GPS required
Distance Travelled	Miles	GPS required
Elevation	Feet above sea level	GPS required
Heart Rate Confidence	%	Based on ECG signal quality and other factors
Signal Strength		For Bluetooth & ECHO only.
BioModule Battery Level	% Full charge	N/A
Physiological Status	Red/Orange/Green	Algorithm uses HR, HR, Activity Level
Accelerometer Waveform	g	Single selected subject, 3 axis
Vertical/Lateral/Sagittal Acceleration	g	N/A
Vertical/Lateral/Sagittal Min/Max Acceleration	g	Over previous epoch (1 / 2.5 / 5 s)
Location	Latitude/Longitude	GPS required. Map display.
Workout Zone	Color coded	4-color. Based on Robbins Periodization system.
Training Zone	Color coded	4-color.
Average Rate Force Development	Newton/s	Measure of explosiveness
Average Step Impulse	Newton	Measure of efficiency of steps
Average Step Period	Seconds	Step duration
Flight Time	Seconds	Jump time in the air
Peak Magnitude Phi	Degrees	Degrees from vertical of impact direction
Peak Magnitude Theta	Degrees	Degrees from front horizontal of impact direction
Impulse Load	Newton	Total impulse load
Walk Step Count	Count	N/A
Run Step Count	Count	N/A

Bound Count	Count	N/A
Jump Count	Count	N/A
Minor Impacts	Count	Peak accelerometer magnitude between 3g & 7g
Major Impacts	Count	Peak accelerometer magnitude greater than 7g

Available by Downloading Log Data from an individual BioModule™ and exporting to an external .csv file

Parameter	Units	Description
ECG Waveform	Bits	Convertible to mV. 250 / 1000Hz.
Accelerometer Raw Waveform	Bits	3-axis. Convertible to g. 100 Hz.
KML file	N/A	Google Earth file containing location data & embedded vital signs (can also be exported from Analysis module)

### Additional OmniSense™ Analysis Software Parameters

The following parameters are available *in addition to* those displayed in OmniSense™ Live software:

From Fitness Test Analysis	Units	Description
HR @ AT	Beats/minute	From detection of Anaerobic Threshold
BR @ AT	Breaths/minute	From detection of Anaerobic Threshold
VO <sub>2max</sub>	ml/kg/min	Based on Heart & breathing rates
HR <sub>max</sub>	Beats/minute	Maximum heart rate of subject
BR <sub>max</sub>	Breaths/minute	Maximum breathing rate of subject
Heart Rate Recovery	Beats per 30 sec	On cessation of test, stationary subject
%VO <sub>2max</sub> @ AT	%VO <sub>2max</sub>	Accepted performance indicator
Fitness Level	Scale 1 - 10	10 = elite athlete
<b>From Summary Graphs</b>		
Max, Min, Average	All parameters	N/A
Speed	Box Plot	2 <sup>nd</sup> , 9 <sup>th</sup> , 25 <sup>th</sup> , 50 <sup>th</sup> , 75 <sup>th</sup> , 91 <sup>st</sup> , 98 <sup>th</sup> , 100 <sup>th</sup> percentiles
Elevation	Box Plot	2 <sup>nd</sup> , 9 <sup>th</sup> , 25 <sup>th</sup> , 50 <sup>th</sup> , 75 <sup>th</sup> , 91 <sup>st</sup> , 98 <sup>th</sup> , 100 <sup>th</sup> percentiles
Jump time in air	Seconds	Based on jump detection
Jump height	Feet / meters	Based on jump detection
Exercise Time	Duration	N/A
Time above AT	Duration	N/A
Time in HR Zones	% Total Duration	Banded histogram - % time in each zone
Time in Training Zones	% Total Duration	Banded histogram - % time in each zone
Time in Speed Zones	% Total Duration	Banded histogram - % time in each zone
Distance in Speed Zone	% Total Distance	Banded histogram - % time in each zone
<b>From Reports (Group Consolidation Report contains all)</b>		
Average Value		Of all parameters in report
Standard Deviation		Of all parameters in report
Significantly Low Value		Less than 1 STDDEV below average
Significantly High value		More than 1 STDDEV above average
% Time in HR Zones	% Total Time	Time in various zones
% Time > HR@AT	% Total Time	Time operating above Anaerobic Threshold (AT)
% Time < HR@AT	% Total Time	Time operating below AT
Peak HR	Beats/minute	For the session
Average HR	Beats/minute	For the session
Average, Max HRV	ms (STDDEV)	Average, Max in milliseconds 300 beat SDNN values
Average, Max HRR	Beats in 30 seconds	If stationary 30 second intervals detected
Average, Max Core Temp	Degrees C / F	For the session
Time in Training Zones	Duration	Blue/Green/Yellow/Orange/Red zones
Time in Speed Zones	Duration	Purple/Blue/Green/Yellow/Orange/Red zones
Distance	Miles/km	Distance in above zones
Average, Max Speed	Miles or km per hour	For session
Elevation Climb, Descent	Feet / meters	Total climb & descent for session

### BioModule Firmware Versions

BioModule firmware versions are available to support two versions of OmniSense, and the garment options: Zephyr Strap or BioPatch HP.

OmniSense 3.9.7 can be downloaded from the Zephyr Website at:

<https://www.zephyranywhere.com/resources/software-download>

It can be used for 30 days for free.

Enquiries for OmniSense 4.X can be made from the same location as above, A license must be purchased for its use.

Firmware Version	OmniSense Version	Garment Type	Description
1.4.5.0	3.9.7	Zephyr Strap – BH3 Side (left side)	<ul style="list-style-type: none"> <li>Summary data packets &amp; Log formats</li> </ul>
1.4.5.400	3.9.7	BioPatch HP – BH3 Front (front upright)	
1.5.0.0	4.1.6	Zephyr Strap – BH3 Side (left side)	<ul style="list-style-type: none"> <li>Enhanced Summary data packets &amp; log formats</li> <li>In-device impact analysis</li> </ul>
1.5.0.201	4.1.6	BioPatch HP – BH3 Front (front upright)	

Future revisions of firmware will support both the Zephyr Strap and BioPatch HP – reprogramming BioModule firmware will not be necessary to switch garment types.

OmniSense can support BioModules worn on straps, and as BioPatches, simultaneously. The transmitted data packets and logged data are identical for equivalent firmware versions.



### Specifications

Unless otherwise stated: Temperature = 25°C, Pressure = 1ATM, fresh battery.

#### Power Supply

- Internal Lithium cell, rechargeable via USB.
- Not replaceable

#### Parameters

	Notes	Min	Typ.	Max	Acc'y	Unit
<b>General</b>						
Logging capacity	1		500+			hours
Power supply voltage	USB	4.5	5	5.5		V
Battery Life – Radio transmitting	2	12		28		hrs
Battery Life - Logging	3		35			hrs
Log Download Time	4	1		6		Min per hr of log
Charging Time			3			hrs
Storage Between charges			6			months
Charging Cycles	5		300			Cycles
ECG Digital resolution	6	10		12		bits
<b>Heart Rate</b>						
ECG sensor sampling frequency			1000			Hz
Range	7	0		240	±1	BPM
R-R		250		1500		ms
Time to first lock	At 60 bpm		15	25		S
No Signal Response time	60 to 0 bpm		10			S
Input dynamic range		0.1		10		mV <sub>pp</sub>
ECG Amplitude	8	0.25		15		mV

#### Operating Modes:

- Active – device transmitting data + logging, if configured  
 Standby – device not transmitting but connectable + logging, if configured

#### Notes:

1. General Logging (Gen + ECG = 140hrs, Gen + Acceleration = 280hrs, Enhanced Summary = 450 hours, Enhanced Summary and Waveform = 55 hours, Enhanced Summary and Development = 30 hours)
2. Min Period – after 180 charge cycles. Max Period – new battery, 802.15.4 Transmit only
3. Software required for data download.
4. Min: General Log only. Max: Enhanced Summary + Development
5. After 300 deep discharge/charge cycles the battery will retain a minimum of 80% of its original capacity.
6. 12 bit sampling. Transmit 10 bit, Log 12 bit.
7. Heart Rate Accuracy for defined activity levels: based on USARIEM\* guidelines

Accuracy (bpm)	Activity Level	VMU	USARIEM % of time	Zephyr % of time	Max Deviation (bpm)
±1	Laboratory – ECG simulator		100	99	1
±2	Low activity (static)	< 0.2	99	99	5
±3	Moderate activity (walk/jog)	< 0.8	95	96	5
±3	High activity (run)	> 0.8	90	96	10

8. Accuracy greater of 100 µV or 10%

\*United States Army Research Institute of Environmental Medicine

	Notes	Min.	Typ.	Max.	Acc'y	Unit
<b>Breathing Rate</b>						
Sampling frequency			25			Hz
Range	9	0		120	±1	BPM
No signal response time			15			s
Step change response time			15			s
<b>Device Temperature</b>						
Sampling frequency	10		1			s
Range		10		60	±2	°C
Stabilization Time			20			minutes
<b>Acceleration</b>						
Sampling Frequency			100			Hz
Range (any axis)		-16		+16		g
<b>Bandwidth</b>						
Sensitivity			12			mg
<b>Activity</b>						
VMU (vector magnitude units)	11			16		g
Epoch			1			s
Bandwidth		0.06		9		Hz
Dynamic Range (any axis)		-16		16		g
Sensitivity			10			mg
Noise			7.2			mg
<b>Posture</b>						
Reporting frequency			1			Hz
Dynamic Range	12	-180		+180		Degrees
Epoch			1			s
Sensitivity		8		1		Degrees

Recommended storage temperature 20°C

Notes:

9. Breathing Rate Accuracy for defined conditions: based on USARIEM\* guidelines

Accuracy (Bpm)	Condition (average every 15 seconds)	VMU	USARIEM % of time	Zephyr % of time	Max Deviation (bpm)
±2	Laboratory – breathing emulator		100		2
±3	Low activity (static)	< 0.2	95	75	5
±3	Moderate activity (walk/jog)	< 0.8	95	65	5
±5	High activity (run)	> 0.8	90	75	12
±5	Talking & breathing rate in range 6 – 25 bpm		100		

10. Min = device transmitting, Max = device logging

11. Vector Magnitude Units, 3-axis, sampled at 100 Hz, averaged to 1 second epoch.

12. 0° = vertical, 90° = horizontal. 180° = inverted. Subject anterior inclination is a positive value, posterior is negative. Mediolateral inclination does not affect sign of posture value (i.e. sideways tilt).

### RF Characteristics

#### Bluetooth

Bluetooth Compliance	Version 2.1 + EDR
Supported Profile	Serial Port
Discoverability	Configurable

Bluetooth Compliance	Version 4.0
Supported GATT Services	Heart Rate, Device Information, Zephyr™ Proprietary
Discoverability	Configurable

Frequency	2.4 to 2.835 GHz
Output Power	10 dBm
Operating Range	Up to 300ft / 100m. Up to 300yds with long range receiver antenna (Dependent on Bluetooth receiver components)
Sensitivity	-91 dBm
Antenna Type	Internal

#### 802.15.4 (Zephyr ECHO Network)

Compliance	IEEE 802.15.4
Frequency	2.405 – 2.480 GHz
Output Power	100mW
Operating Range	Up to 300 yards / 275 m
Sensitivity	-89 dBm
Max Data Rate	250 kbps
Modulation Type	OQPSK
Spread Spectrum	DSSS

#### ROG Subject Status Indication

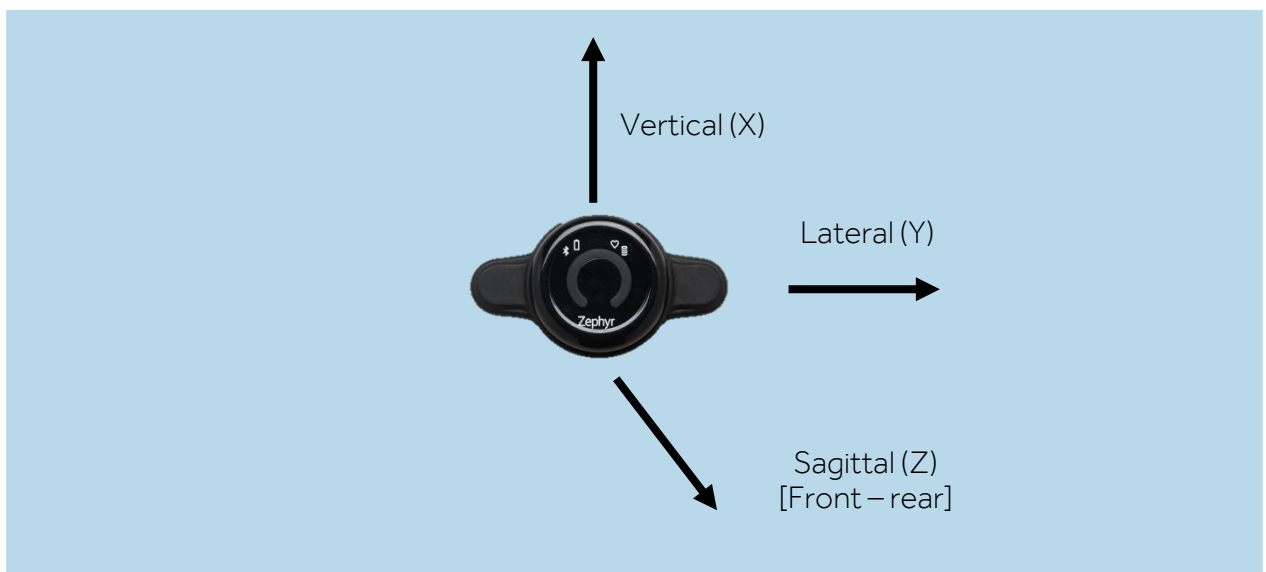
This is a value which is calculated in the device. It is dependent upon four fixed, subject-configurable thresholds:

- Heart Rate minimum
- Heart Rate Maximum
- Breathing Rate Minimum
- Breathing Rate Maximum

Current and previous Heart Rate and Breathing Rate values are used in conjunction with activity level to establish a subject's status, using Zephyr™ proprietary algorithms.

Threshold levels are stored within the device and are configurable by USB.

### Accelerometer Axis Orientation



### Standards/Compliance/Certification

The BioModule has been designed to conform to the following:

RTTE	Directive 1999/5/EC
FCC ID	VZ6-BH3
IC ID	7565B-BH3
Contains Bluetooth Transmitter Module	
FCC ID	T7V1316
IC ID	216Q-1316

Compliance Marks	   
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### Environmental

Operating Temperature	-30°C / +60°C
Storage Temperature	-40°C / +85°C
Charging Temperature	0°C / +45°C
ESD	IEC 801-2KV
Ingress Rating	IP67

### Mechanical

Dimensions	BioModule™	28 (Diam) x 7 mm (1.85 x 0.46 inches)
	Charging Cradle (Single device)	80w x 24d x 37h mm (2.5 x 1.6 x 1.1 inches)
Weight	Holder	14.2 grams
	BioModule™	18 grams
Case Material	PC	Polycarbonate

### Accessories

Component	ZPN
Zephyr™ BioModule (BLE)	9600.0370
Zephyr™ BioModule Holder	9600.0189
Zephyr™ Single Bay BioModule Charging Cradle	9600.0257
Zephyr™ 5-Bay BioModule Charging Cradle	9600.0333

### FCC Declaration

NOTE: THE MANUFACTURER IS NOT RESPONSIBLE FOR ANY RADIO OR TV INTERFERENCE CAUSED BY UNAUTHORIZED MODIFICATIONS TO THIS EQUIPMENT. SUCH MODIFICATIONS COULD VOID THE USER'S AUTHORITY TO OPERATE THE EQUIPMENT.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

(1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Any computer used in conjunction with this device must be covered by a Declaration of Conformity or must be FCC certified in its own right.

### FAQs - BioModule™

**Q** How long will the battery last?

**A** It varies slightly according to how much data you are logging and transmitting, but a new battery should last 30+ hours.

**Q** What does a constant red LED indicate?

**A** Heart rate has not been detected. Re-prepare skin and re-apply the BioPatch HP with new electrodes if necessary.

**Q** What does a constant blue LED indicate?

**A** Communications error. Confirm you are in range of any receiving device. If you have updated firmware, the device may contain the wrong firmware image. Contact Zephyr™ support.

**Q** What does a constant orange LED indicate?

**A** Low battery (less than 10%). Recharge in cradle.

**Q** Does the BioModule™ have a clock? How accurate is it?

**A** The BioModule™ has an internal quartz crystal for timing, but we recommend you use the Zephyr™ Config Tool to re-synchronize the device clock with PC before use. OmniSense™ Analysis does this automatically every time logs are imported.

**Q** Can I replace the battery?

**A** The battery isn't replaceable, but should provide many years of use. See the Care and Maintenance section for tips on preserving your battery life.

### Troubleshooting

#### The red LED remains on all the time.

- Heart rate is not being detected from the ECG signal
- Poor conductivity to the electrodes may be the cause – replace the electrodes and re-prepare the skin
- If the BioModule™ has been well-used, the spring contacts on the rear of the device may have become slightly depressed, causing poor contact with the holder. Carefully lift the springs. They must not protrude so much as to catch on the edge of the charge cradle when inserted.

#### The blue LED remains on all the time.

- If firmware has been recently updated, the firmware version for the wrong generation BioModule™ may be installed.

#### The orange LED is flashing

- Battery level is below 10%

#### Heart rate is higher than it should be

- Poor conductivity may result in a noisy ECG signal causing an invalid heart rate
- If possible, check the Heart Rate Confidence in a log file or transmitted data. – this may confirm a poor quality signal.
- Replace the ECG electrodes and re-prepare the skin
- *Excessively* active subjects may also cause noise in the signal due to adjacent muscle movement

### Limited Warranty for the Zephyr™ BioPatch HP monitoring device

Zephyr™ Technology Corporation warrants to the original end purchaser that:

- the BioPatch™ HP BioModule hardware shall be free from material defects in material and workmanship for a period of one (1) year from the original date of purchase (the "Hardware Warranty Period")
- the BioPatch™ HP BioModule Holder shall be free from material defects in material and workmanship for a period of 90 days from the original date of purchase (the "BioModule™ Holder Warranty Period")

If the product is determined to be materially defective during the Warranty Period, your sole remedy and Zephyr's sole and exclusive liability shall be limited to the repair or replacement of this product with a new or refurbished product at Zephyr's or its licensed distributor's option. For purpose of this Limited Hardware Warranty and Liability, "refurbished" means a product that has been returned to its original specifications. Visit [www.zephyranywhere.com](http://www.zephyranywhere.com) for instructions on how to deliver the product to an authorized service facility.

This warranty shall not apply if this product

- a) is used with products that are not compatible with this product
- b) is modified, or tampered with
- c) is damaged by acts of God, misuse, abuse, negligence, accident, wear and tear, unreasonable use, or by other causes unrelated to defective materials or workmanship
- d) has had the serial number altered, defaced or removed
- e) has, in the reasonable opinion of Zephyr™ or its licensed distributors, been opened, altered, or defaced.

This warranty shall also be voidable by Zephyr™ or its licensed distributors

If (1) Zephyr™ reasonably believes that the BioPatch™ HP monitoring device has been used in a manner that would violate the terms and conditions of a separate end user license agreement for system software; or (2) the product is used with products not sold or licensed by Zephyr™. You assume all risks and liabilities associated with use of third party products.

This warranty is provided to you in lieu of all other express or implied warranties including warranties of merchantability and fitness for a particular purpose for the BioPatch™ HP monitoring device, which are disclaimed hereunder. However, if such warranties are required as a matter of law, then they are limited in duration to the warranty period.

Our sole and exclusive recourse in the event of any dissatisfaction with or damage arising from the use of the BioPatch™ HP monitoring device and Zephyr's maximum liability shall be limited to repair or replacement of the BioPatch HP. Except as expressly stated above, Zephyr™ excludes all liability for any loss of data, loss of profit, or any other loss or damage suffered by you or any third party, whether such damages are direct, indirect, consequential, special, or incidental and however arising under any theory of law, as a result of using your BioPatch HP. Some countries, states or provinces do not allow limitation on how long an implied warranty lasts and some countries, states and provinces do not allow the exclusion or limitations of consequential or incidental damages, so the limitations or exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from country to country, state to state or province to province. This warranty is in all countries where Zephyr™ has an office or a licensed distributor. The warranty offered by Zephyr™ Technology Corporation on your BioPatch™ HP monitoring device hardware is the same whether or not you register your product.