BioHarness Bluetooth API Guide

Document History

Version	Date	Description
1.1	14th Jan 2008	Initial draft for review
1.2	15th Jan 2008	Updated after review – added table of messages supported by the protocol with indication of currently implemented messages.
1.3	25th Mar 2008	Added information on Accelerometer Data Packets.
1.4	6th May 2008	Updated Fig 5.5 for altered gain devices
1.5	7th May 2008	Remove unsupported messages Section 7.
1.6	8th May 2008	Added Section 8
1.7	13th may 2008	Added Part No.
1.8	26th Mar 2009	Updated Sections 4.3 & 6.3 referring to Link Timeouts & Lifesign messages to match Firmware v1.0.0.0 Updated Section 7
1.9	31 May 2010	Refer to BioH BT Comms Link Specification throughout.Change Sections 7 & 8 to refs to other docs. New footer.

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.

1. References

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

2. Abbreviations

Abbreviation	Description
API	**A**pplication **P**rogrammer's **I**nterface
ECG	**E**lectro**C**ardio**G**ram
PC	**P**ersonal **C**omputer
RTC	**R**eal **T**ime **C**lock
SPP	**S**erial **P**ort **P**rofile

3. Introduction

This document is intended as a user's guide for implementing an API to enable communications with a Zephyr Technology™ Bluetooth BioHarness. The guide should be used in parallel with the *BioHarness Bluetooth Comms Link Specification* **[1]** to develop applications that communicate with the BioHarness. Use of sequence diagrams has been utilized throughout to describe the communication transfers.

The main streaming data transfer packets are described within this document e.g. ECG waveform, although there are several other messages that can be used which are mainly non-streaming (in request/response form). These are not described in any great detail here, but are in the *BioHarness Bluetooth Comms Link Specification* **[1]** e.g. the "Set RTC" command.

A detailed description of all messages utilized by the BioHarness, including the protocol used is available in the *BioHarness Bluetooth Comms Link Specification* **[1]** where all data content and formatting is clearly specified. This document is intended as a high-level guide to developing an API for communicating with the BioHarness.

4. System Overview

4.1. System Architecture

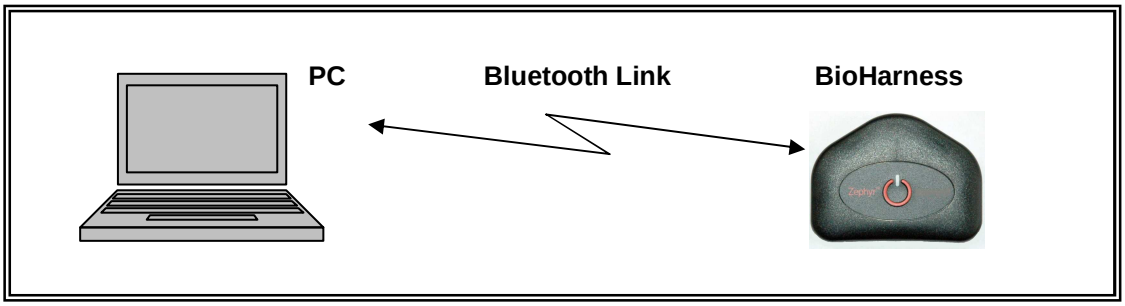

Figure 4.1 BioHarness Bluetooth System Architecture

The diagram above shows that the Bluetooth BioHarness typically communicates with a PC over the Bluetooth link, although any Bluetooth enabled device could potentially provide a link to the BioHarness. The BioHarness only supports one link at a time and uses the Bluetooth **SPP** (Serial Port Profile) to communicate with other devices with the following low-level protocol:

- 115,200 baud
- 8 data bits
- 1 stop bit
- No parity

4.2. Security

The BioHarness currently utilizes a Bluetooth security pin code of "**1234**".
Therefore every time the PC connects to a freshly powered-up BioHarness unit, the PC must transfer the pin code settings before the link can be established.

4.3. Link Timeouts

To guard against link failures, a configurable timeout has been implemented on the BioHarness link. By default, If no packets are received for more than 10 seconds, the link will be dropped by the BioHarness. If the remote device that is connected to the BioHarness also has a link timeout implemented, the Bioharness can be configured to send a periodic "Lifesign" packet to keep the link active (by default it is sent every 3 seconds).
If link timeouts are not required, the BioHarness link timeout and Lifesign period can both be set to 0; this means that the Bioharness will never timeout and will never send Lifesign messages.

5. Data Packets

The BioHarness utilizes a simple request/response (ACK) link transfer mechanism for most of the packets it processes, with the exception of streaming data packets which have no ACK associated with the data transferred due to the amount of real-time data being transferred and the delays that would be incurred.
The streaming data packets must be enabled individually before the BioHarness starts to send each to the PC; therefore the BioHarness can be sending any or all of the packets. The following table briefly describes the streaming data packets that can be enabled:

Streaming Packet Type	Transmission Period	Description
General Data	1008 ms	Low resolution data e.g. Heart Rate, Skin Temperature, Breathing Rate.
Breathing Waveform	1008 ms	Sampled breathing waveform with a resolution of 56ms.
R to R Data	1008 ms	Sampled R to R data calculated from the ECG with a resolution of 56ms.
ECG Waveform	252 ms	Sampled ECG waveform with a resolution of 4ms.
Accelerometer Waveforms	400ms	Sampled X, Y & Z accelerometer waveforms with a resolution of 20ms.

Table 5.1 Streaming Data Packets.

5.1. General Data

Data items with a resolution of 1.008 seconds; typically this packet comprises calculated values within the BioHarness, for example:

- Heart Rate
- Breathing Rate
- Skin Temperature
- Activity
- Posture
- Battery Voltage

The packet is sent to the PC every 1.008 seconds.

5.2. Breathing Waveform

Contains samples of analog data; the samples are taken from an Analogue to Digital Converter every 56ms. Reassembling these samples on reception at the PC will enable a graphical representation of the breathing waveform.

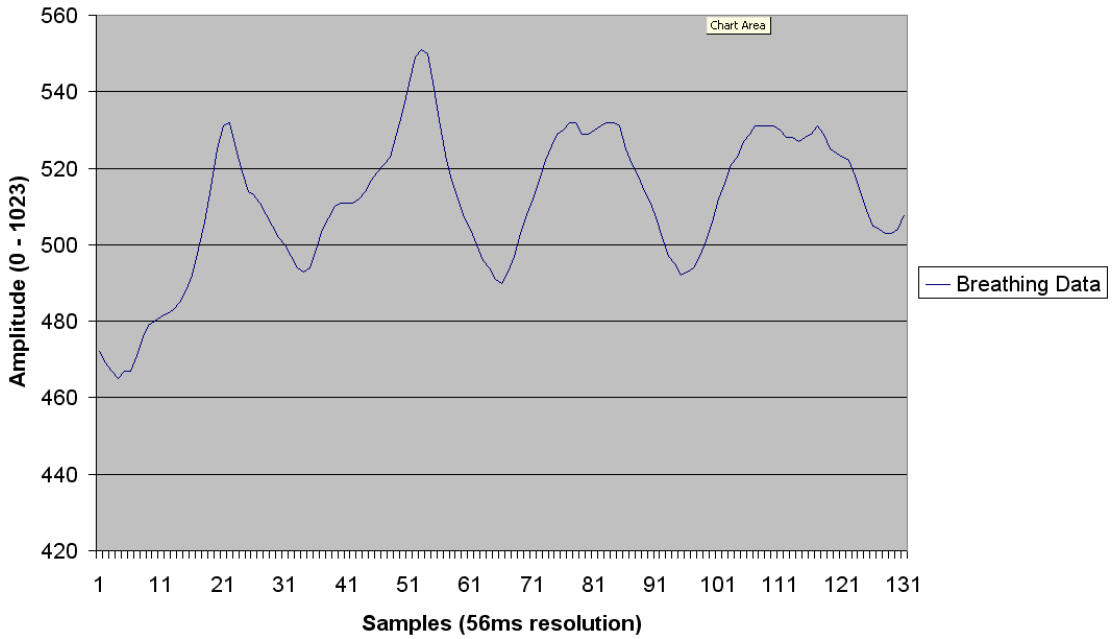

Figure 5.2 Breathing Waveform example.

The plot of the received raw data from the Breathing waveform packet shows the breathing signal can be reassembled. The amplitude of the signal ranges between a minimum value of 0 and a maximum of 1023.

5.3. R to R Data

Contains samples of R to R periods. The R to R period is stored within the BioHarness every 56ms; therefore the values in this packet are static until another QRS wave complex has been recognized.

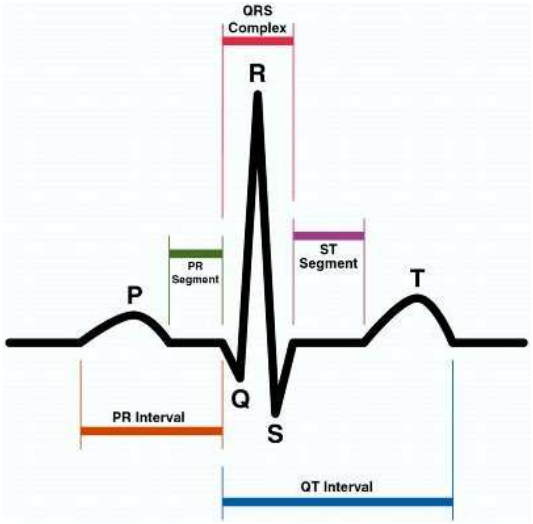

Figure 5.3 PQRS Waveform complex.

The R to R period is the time between subsequent R peaks in an ECG waveform.

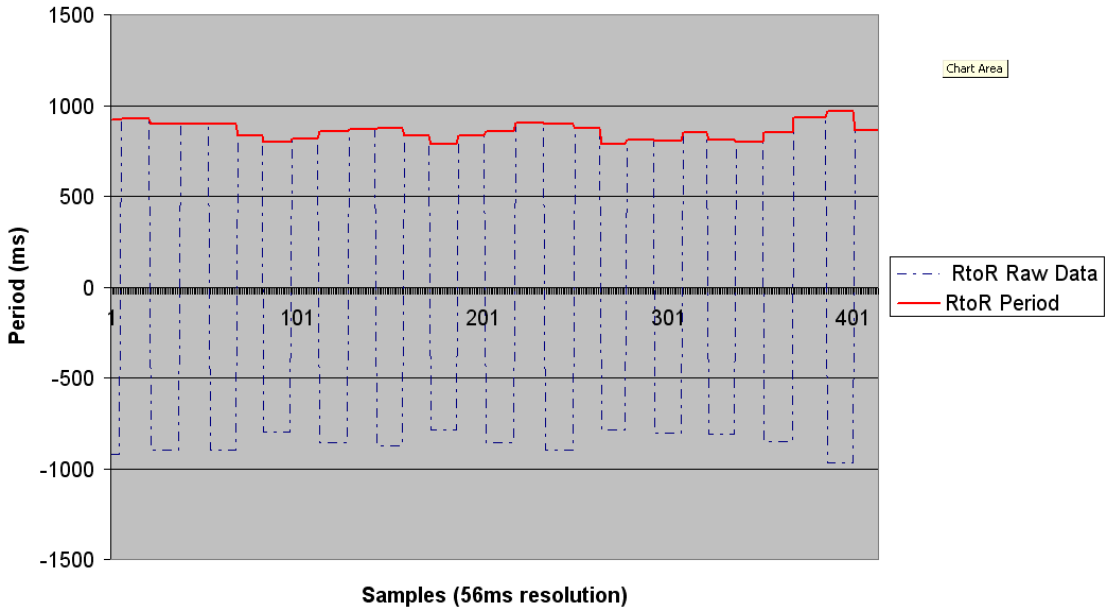

Figure 5.4 R to R Waveform example.

When the raw data is plotted, one can see that the raw data (blue dotted trace) changes sign every time the R to R period is changed (when a new QRS complex has been recognized). Therefore the sign must be removed from the raw data to view the actual R to R period (in milliseconds), as seen in the solid red trace. Each sample is separated in time by 56ms.

5.4. ECG Waveform

Contains samples of analog data; the samples are taken from an Analogue to Digital Converter every 4ms. Reassembling these samples on reception at the PC will enable a graphical representation of the ECG waveform:

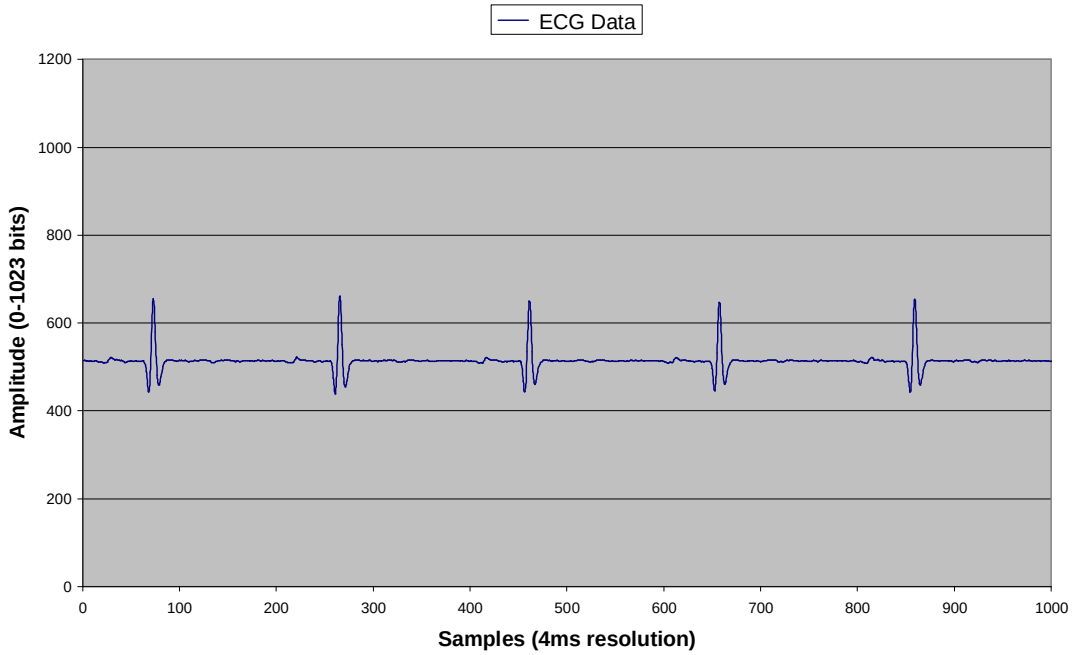

Figure 5.5 ECG Waveform example.

A plot of the raw data shows the reassembled ECG waveform.

5.5. Accelerometer Waveforms

Contains samples of analog data; the samples of each axes are taken from an Analogue to Digital Converter every 20ms. Reassembling these samples on reception at the PC will enable a graphical representation of the Accelerometer waveforms:

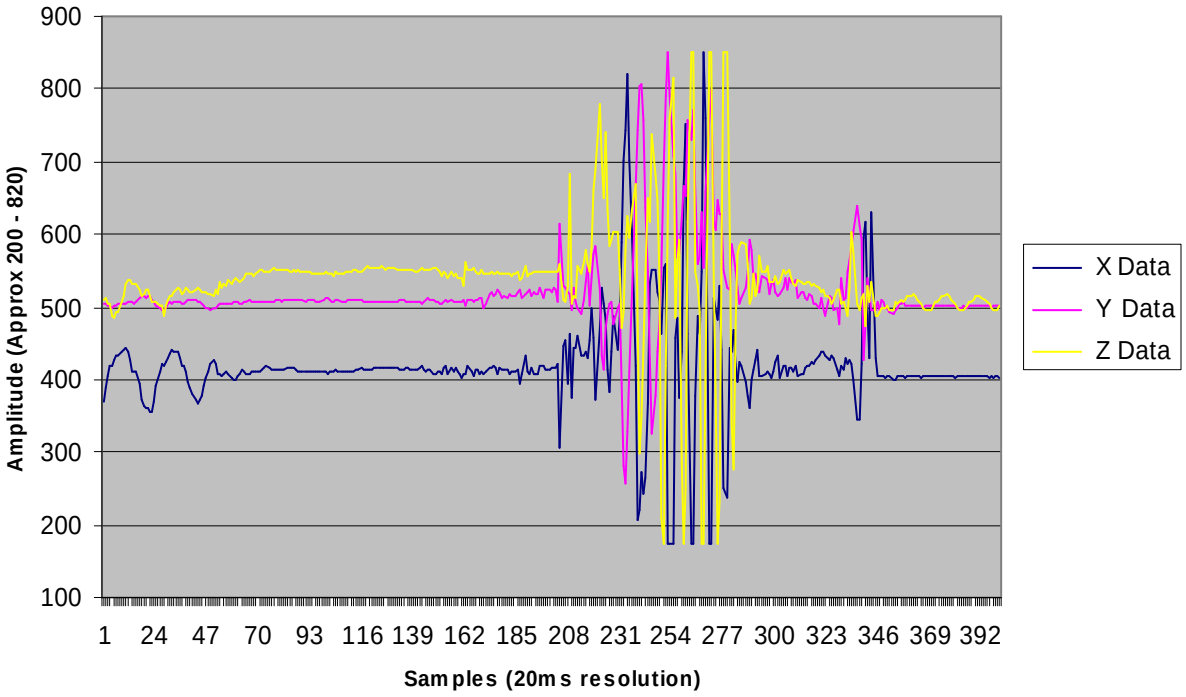

Figure 5.6 Accelerometer Waveforms example.

The plot of the received raw data from the Accelerometer waveform packet shows the reassembled X, Y & Z data. The amplitude of the signals ranges between approximately 200 (-3g) and 820 (+3g) with the 0g value being approximately 511.

5.6. Packet Enable/Disable Commands

Streaming Packet Type	Enable/Disable Command
General Data	Set General Data Packet Transmit State
Breathing Waveform	Set Breathing Waveform Packet Transmit State
R to R Data	Set R to R Data Packet Transmit State
ECG Waveform	Set ECG Waveform Packet Transmit State
Accelerometer Waveforms	Set Accelerometer Packet Transmit State

Table 5.2 Streaming Packets and their associated Enable/Disable Commands.

The table above gives a brief summary of the streaming packets and the commands used to enable or disable them. See the *BioHarness Bluetooth Comms Link Specification* **[1]** for more detail on the message content.

6. Link Transfers

6.1. Packet Enabling/Disabling

Once a Bluetooth connection has been established, the streaming data packets can be enabled or disabled by the PC. Each packet can be enabled or disabled via command messages to the BioHarness. The following sequence diagram shows an example session:

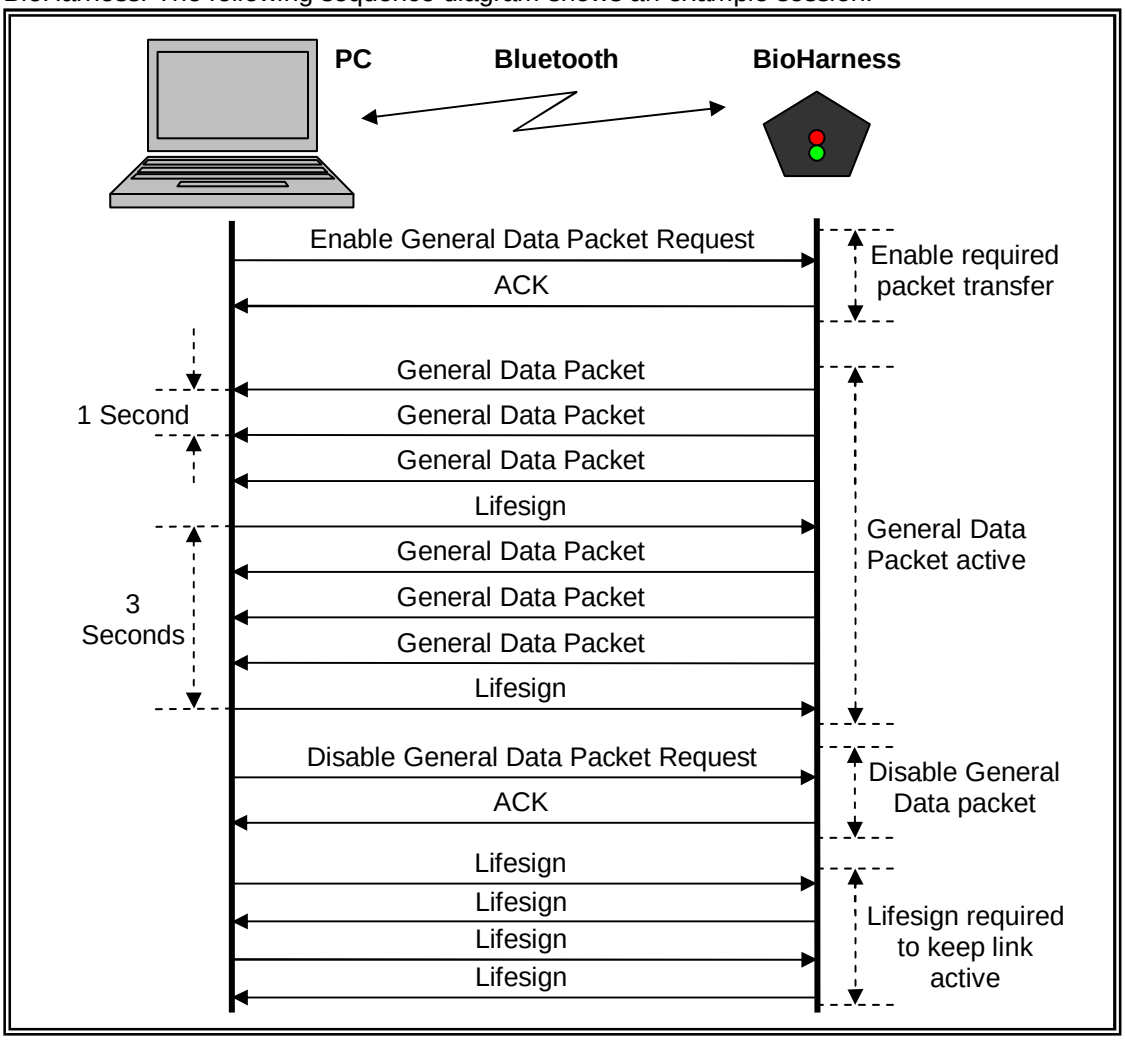

Figure 6.1 Example link session.

The diagram shows that after the PC has connected to the BioHarness it sends a command to enable the “General Data” packet which the BioHarness responds to with an acknowledgement and subsequently starts sending periodic General Data packets to the PC (every 1.008 seconds). The PC continues to send periodic Lifesign messages if it has no other messages to send to the Bioharness. After the session is complete, the PC sends a command to stop the General Data packet which again initiates an acknowledgement from the unit. In this example, the BioHarness is configured to send Lifesign messages to keep the link with the PC active. The R to R Data,

Breathing, ECG Waveform and Accelerometer packets are enabled in the same manner as the General Data packets.

6.2. Standard Request/Response Messages

In addition to the streaming data packets sent by the BioHarness, there are several other messages that can be utilized on the BioHarness. For example, the RTC (real time clock) can be updated to ensure that the BioHarness time matches the PC time. Streaming data packets sent by the BioHarness have a timestamp within the packet to indicate when the packet was assembled in the BioHarness prior to transfer to the PC, therefore it may be important to ensure the RTC matches the PC time; this could be set every time the link is established.
Software versions and part numbers can also be retrieved from the BioHarness over Bluetooth if required (see **[1]** for more details).

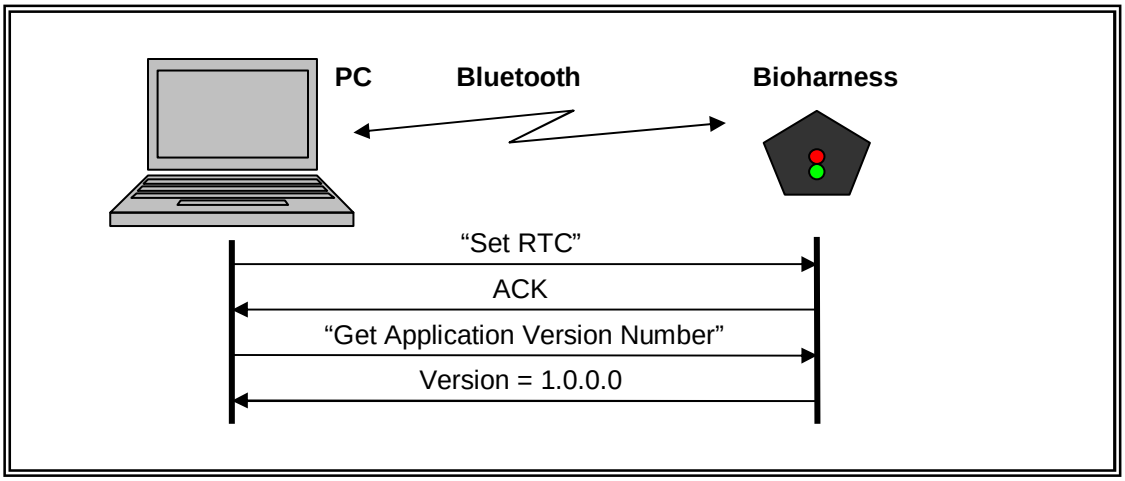

Figure 6.2 Simple Request/Response message transfer example.

The example above shows two simple data transfers, one to set the BioHarness RTC to the required date/time and the second to retrieve the Application Software Version number. Both messages are detailed in the *BioHarness Bluetooth Comms Link Specification* **[1]**.

6.3. Link Timeouts

If there are no scheduled periodic messages e.g. General Data Packet passing between the PC and BioHarness, a Lifesign message can be configured to be sent periodically to indicate to the remote device that the BioHarness has not locked-up. The Lifesign message is sent to ensure a timeout doesn't occur (which would lead to the remote unit closing the link).
A timeout is recognized if a local unit hasn't received a message from a remote device for more than a pre-defined time which in this case is 10 seconds. If this occurs, the local device closes the connection and assumes that the remote device is faulty. In the scenario where radio interference impedes the transfer of data with a Bio Harness and the link is closed, the PC can attempt to reconnect to the device.

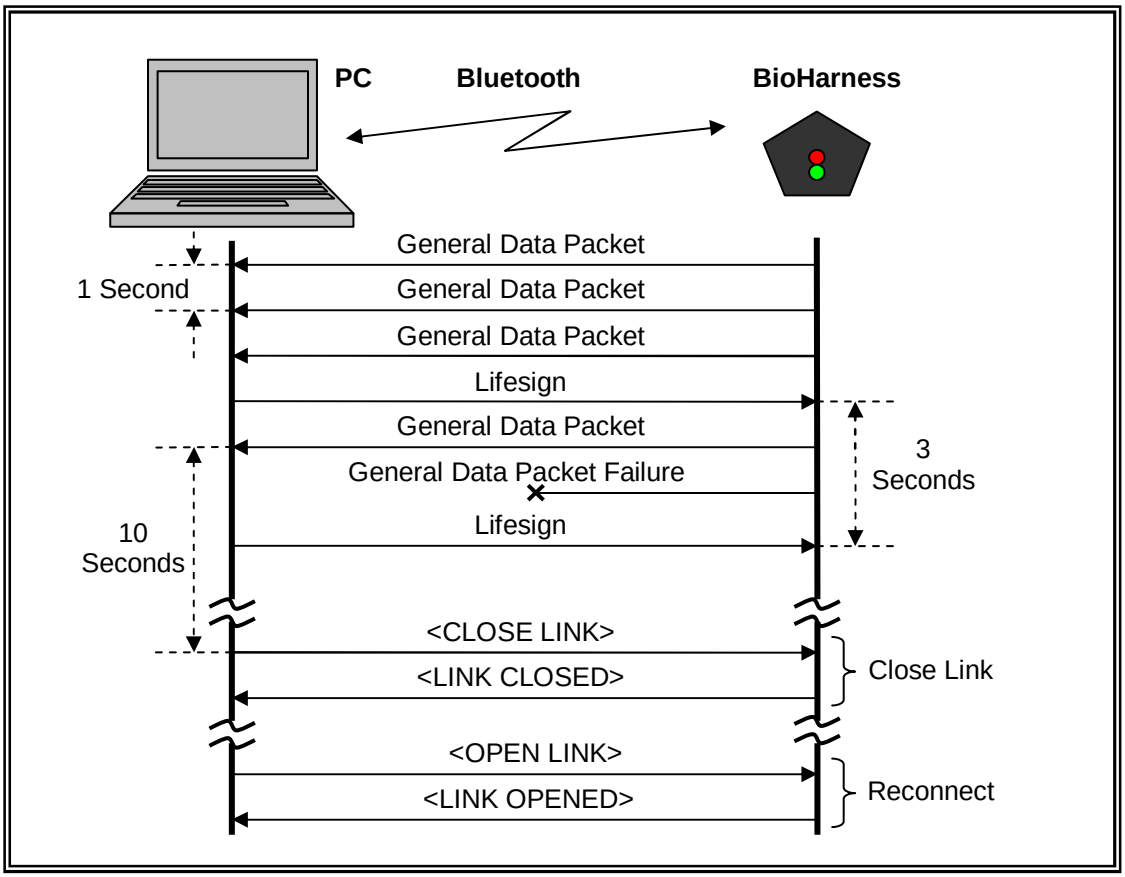

Figure 6.3 Link Timeout Processing

The diagram above shows a situation where the PC stops receiving data from the Bio Harness. 10 seconds after receiving the last data from the Bio Harness, the PC closes the Bluetooth link; it subsequently attempts to reconnect and re-establish communications. Likewise, if the PC were to stop communicating with the BioHarness for any reason, after a pre-configured timeout, the BioHarness would close the link and wait for re-connection unless the timeout was configured to 0 in which case it would never timeout and therefore not close the link.

7. Currently Implemented Messages

A full list of supported messages in included in the *BioHarness Bluetooth Comms Link Specification* **[1]**

8. Log Record Format

The Log File Format is described in the *BioHarness Bluetooth Logging System Interface* **[2]** document.