6/6/2013

# LifeBand Communications Protocol and Commands v5.0

# TABLE OF CONTENTS

# I.  Introduction

The LifeBand sensor bands are a set of wearable sensors that used to measure a variety of physiological data parameters.

# II. Available options for downloading and viewing data from Sensor Bands

## A.  Using the Sensor Band with a mobile phone via Bluetooth

Most Ashametrics Lifeband devices are designed to interface with mobile phones.  The LifeBand devices support Bluetooth v2.0, with Bluetooth version 4.x (Low Energy) available in the near future.

This document describes how to parse the incoming Bluetooth data packets for people who are writing their own software to receive the incoming data packets via Bluetooth.

If you are using an Ashametrics sensor band with an Ashametrics mobile app, the data will be automatically saved on the phone in a .csv file format.  For this case, you should refer to another document titled "Ashametrics Stored Data Formats for Mobile Phone Apps."

## B.  Using the Sensor Band with a PC via USB

Ashametrics sensor bands can be plugged into a PC via USB to download the data or to view live data.  With the appropriate USB driver (available from Ashametrics), the sensor band will appear as a virtual COM port when it is plugged into the PC.  The user can then view the list of available files and download files using simple commands.  However, the simplest way to download and view the data from a sensor band is to use the Windows Lifeband software available from Ashametrics.

## C.  Using the Sensor Band with a PC via Bluetooth

PC computers do not have standard Bluetooth radios or Bluetooth software stacks.  As a result the Bluetooth implementation is quite fragmented.

However, there are many Bluetooth USB devices which you can use to connect the Lifeband to your PC.  For example, you can browse any online computer supplies store (e.g. Fry's electronics, Radio Shack, etc.) or if you are a hacker, a simple online resource is: Sparkfun.com

At present, (this may change in the future) the wireless packet protocol from the band is ASC text (not binary), so it is relatively simple to view data and interact with the sensor band via any terminal program using a virtual com port with the Bluetooth USB or with the built-in Bluetooth on your PC.

## D. Using the Sensor Band with a Macintosh via Bluetooth

Macintosh computers have built-in Bluetooth radios and, unlike PC's, the Bluetooth implementation are identical on most Macintosh computers, which provides an advantage for development and debugging.

In order to communicate with the sensor, you must set up a Bluetooth COM port on the computer. You can then use any terminal program to open the serial connection and change settings. Sample programs (which are free) are: Coolterm, Terraterm, etc.

# III.Types of Sensor Bands – Summary

There are currently 7 types of wireless data packets that are generated by Ashametrics sensor bands. Some bands can generate more than one type of data packet.

**Why does Ashametrics create some sensor bands that have multiple types of data packets?**

Since Ashamettrics customers have different needs for sensor bands, Ashametrics enables the customer to choose which type of data packet is the best match for your needs. For example, some customers prefer that the sensor band itself calculate heart rate and heart rate variability. Other customers prefer to see the actual heart waveform and post-process the data themselves.

The different data formats and types of sensor bands are listed below. The data format, or data "mode" , is indicate by a protocol byte in the data packet header.

- **Type 0** – Basic sensor band (usually wrist of ankle band), which measures EDA, Temp, and accelerometer.
- **Type 1** – Heart rate monitor (ECG) – calculates IBI (inter-beat intervals) and transmits over Bluetooth the IBI information in groups of 8 per data packet.
- **Type 2** – Heart rate monitor (ECG) – calculates the current IBI and average IBI and continuously transmits a these two parameters in each data packet.
- **Type 3** – Heart Rate monitor (ECG) – this mode of operation is used to collect the heart waveform data (which is sampled at approx 320 Hz.) (this mode does not compute any IBI's – it is just the waveform)
- **Type 4** – This mode is used for wrist/ankle bands that include a heart rate monitor (using photoplethysmography). Data includes EDA, Temp, and accelerometer, plus PPG heart rate sensor with pulse oximetry (Same parsing as Type 0)
- **Type 5** – Multi-parameter device which measures heart rate (ECG), EDA, Temp, and 3-axis accelerometer.
- **Type 6** – Heart Rate monitor (PPG – photoplethysmography). The band samples the optical signal at 320 Hz and streams this data out over Bluetooth. This is used to study the PPG waveform.
- **Type 7** – Wrist or ankle band Sensor band which includes: EDA, skin temp, ambient temp, ambient humidity, and 3-axis accelerometer. This sensor band streams data out over Bluetooth.
- **Type 8** – Wearable light monitor – This device is generally worn in the form of a necklace or pendant and is designed for measuring ambient light exposure. The data from this device includes: Total visible light (lux), Infrared light, Blue light level, Red light level, Green light level, 3-axis acceleration, temperature, and sound level.

# IV. Data Packet parsing for LifeBand Sensor bands

If you are working with the data collected on the internal sensor band memory card or the raw data packets collected from an Ashametrics mobile phone app, this section describes how to interpret this data.

## A. Sensor Type 0

This sensor band contains:

- EDA – electrodermal activity sensor
- 3-axis accelerometer
- Temperature sensor

Sample data packet:

* 0000 7F 0000012EC986A580 0FFF 0EBD 0EE5 0384 015F 0E9D FFFF FFFF 7C <CR> <LF>

PACKET HEADER SENSOR DATA

Packet Parsing:

* = start character (asterisk)

0000 = Packet Type/Format (indicates formatting of sensor data)

7F = packet counter (this is increments continuously)

0000012EC986A580 = Timestamp in milliseconds since January 1, 1970 (this one happens to be = March 18, 2011 3:12:48.000 pm)

0FFF = Accelerometer x-axis

0EBD = Accelerometer y-axis

0EE5 = Accelerometer z-axis

0384 = Temperature

6/6/2013

015F = $EDA_P$

0E9D = $EDA_{BIAS}$

FFFF = Heart Rate

FFFF = PO2 Sat

7C = Additive checksum of packet mod 256

Note: The data in this example is taken with the EDA sensor off the body. In this case, both ADC values should read approximately the same. Due to noise, $EDA_P$ is slightly bigger than $EDA_{BIAS}$. However, when the sensor is worn on the body, $EDA_P$ is significantly smaller than $EDA_{BIAS}$. If you are using the LifeBand PC software, then when the user sets up the data filter, the correct channels should be picked so that the Total EDA is not negative.

## B. Sensor Type 1

This sensor band contains:

- ECG heart Rate sensor

This sensor internally detect the individual heart beats and sends a data packet containing the interbeat intervals (IBI's) in groups of 8.

Sample data packet:

* 0001 7F 0000012EC986A580 0012 03FA 07E2 0BCA 0FB2 139A 1782 1B6A 7C <CR> <LF>

PACKET SENSOR

Packet Parsing:

* = start character (asterisk)

0001 = Packet Type/Format (indicates formatting of sensor data)

7F = packet counter (this is increments continuously)

0000012EC986A580 = Timestamp in milliseconds since January 1, 1970 (this one happens to be = March 18, 2011 3:12:48.000 pm)

0012 = 8th most recent heartbeat offset in milliseconds, referenced from most recent minute of timestamp. In this case, the most recent minute is 3:12 pm, so the heartbeat timestamp is 3:12:00.018 pm

03FA = 7th most recent heartbeat offset in milliseconds, referenced from most recent minute of timestamp. In this case, the most recent minute is 3:12 pm, so the heartbeat timestamp is 3:12:01.018 pm

07E2 = 6th most recent heartbeat offset in milliseconds, referenced from most recent minute of timestamp. In this case, the most recent minute is 3:12 pm, so the heartbeat timestamp is 3:12:02.018 pm

0BCA = 5th most recent heartbeat offset in milliseconds, referenced from most recent minute of timestamp. In this case, the most recent minute is 3:12 pm, so the heartbeat timestamp is 3:12:03.018 pm

6/6/2013

0FB2 = 4th most recent heartbeat offset in milliseconds, referenced from most recent minute of timestamp. In this case, the most recent minute is 3:12 pm, so the heartbeat timestamp is 3:12:04.018 pm
139A = 3rd most recent heartbeat offset in milliseconds, referenced from most recent minute of timestamp. In this case, the most recent minute is 3:12 pm, so the heartbeat timestamp is 3:12:05.018 pm

1782 = 2nd most recent heartbeat offset in milliseconds, referenced from most recent minute of timestamp. In this case, the most recent minute is 3:12 pm, so the heartbeat timestamp is 3:12:06.018 pm

1B6A = most recent heartbeat offset in milliseconds, referenced from most recent minute of timestamp. In this case, the most recent minute is 3:12 pm, so the heartbeat timestamp is 3:12:07.018 pm

Since the current timestamp is over 40 seconds after the most recent heartbeat, presumably the sensor band has been removed after 3:12:07 in this example.

## C. Sensor Type 2

This sensor band contains:

- ECG heart Rate sensor

Sample data packet:

* 0002 7F 0000012EC986A580 0FFF 0EBD 0EE5 0384 015F 0E9D FFFF FFFF 7C <CR> <LF>

PACKET SENSOR

NOTE: The data packets from this sensor contain fields (place holders) for other sensors, but these fields can be ignored.

Packet Parsing:

* = start character (asterisk)

0002 = Packet Type/Format (indicates formatting of sensor data)

7F = packet counter (this is increments continuously)

0000012EC986A580 = Timestamp in milliseconds since January 1, 1970 (this one happens to be = March 18, 2011 3:12:48.000 pm)

0FFF = Accelerometer x-axis = set to FFFF

0EBD = Accelerometer y-axis= set to FFFF

0EE5 = Accelerometer z-axis= set to FFFF

0384 = Temperature= set to FFFF

015F = $EDA_P$= set to FFFF

0E9D = $EDA_{BIAS}$= set to FFFF

FFFF = IBI Instant

FFFF = IBI Average

7C = Additive checksum of packet mod 256

## D. Sensor Type 3

This sensor band contains:

- ECG heart Rate sensor

This sensor samples the real-time heart waveform and records/transmits the 12-bit ADC-sampled values.

Sample data packet:

* 0003 7F 0000012EC986A580 084F 0823 0855 0876 0846 0825 0854 0878 7C <CR> <LF>

PACKET ADC values

NOTE: The data packets from this sensor contain fields (place holders) for other sensors, but these fields <u>can be ignored</u>.

Packet Parsing:

* = start character (asterisk)

0003 = Packet Type/Format (indicates formatting of sensor data)

7F = packet counter (this is increments continuously)

0000012EC986A580 = Timestamp in milliseconds since January 1, 1970 (this one happens to be = March 18, 2011 3:12:48.000 pm)

The following 8 16-bit values are ADC samples of the heart waveform

## E. Sensor Type 4

This sensor band contains:

- EDA – electrodermal activity sensor
- 3-axis accelerometer
- Temperature sensor
- PPG heart Rate Sensor

Sample data packet:

* 0004 7F 0000012EC986A580 0FFF 0EBD 0EE5 0384 015F 0E9D 03E8 03E0 7C <CR> <LF>

PACKET SENSOR

Packet Parsing:

* = start character (asterisk)

0004 = Packet Type/Format (indicates formatting of sensor data)

7F = packet counter (this is increments continuously)

0000012EC986A580 = Timestamp in milliseconds since January 1, 1970 (this one happens to be = March 18, 2011 3:12:48.000 pm)

0FFF = Accelerometer x-axis

0EBD = Accelerometer y-axis

0EE5 = Accelerometer z-axis

0384 = Temperature

015F = $EDA_P$

0E9D = $EDA_{BIAS}$

03E8 = IBI Instant

03E0 = IBI Average

7C = Additive checksum of packet mod 256

## F. Sensor Type 5

This sensor band contains:

- EDA – electrodermal activity sensor
- 3-axis accelerometer
- Temperature sensor
- ECG heart Rate Sensor

Sample data packet:

* 0005 7F 0000012EC986A580 0FFF 0EBD 0EE5 0384 015F 0E9D 03E8 03E0 7C <CR> <LF>

PACKET SENSOR

Packet Parsing:

* = start character (asterisk)

0005 = Packet Type/Format (indicates formatting of sensor data)

7F = packet counter (this is increments continuously)

0000012EC986A580 = Timestamp in milliseconds since January 1, 1970 (this one happens to be = March 18, 2011 3:12:48.000 pm)

0FFF = Accelerometer x-axis

0EBD = Accelerometer y-axis

0EE5 = Accelerometer z-axis

0384 = Temperature

015F = $EDA_P$

0E9D = $EDA_{BIAS}$

03E8 = IBI Instant in milliseconds

03E0 = IBI Average in units of miliseconds

7C = Additive checksum of packet mod 256

## G. Sensor Type 6

This sensor band contains:

- PPG heart Rate Sensor

This sensor samples the real-time heart waveform and records/transmits the 12-bit ADC-sampled values.

Sample data packet:

* 0006 7F 0000012EC986A580 084F 0823 0855 0876 0846 0825 0854 0878 7C <CR> <LF>

PACKET SENSOR

NOTE: The data packets from this sensor contain fields (place holders) for other sensors, but these fields can be ignored.

Packet Parsing:

* = start character (asterisk)

0006 = Packet Type/Format (indicates formatting of sensor data)

7F = packet counter (this is increments continuously)

0000012EC986A580 = Timestamp in milliseconds since January 1, 1970 (this one happens to be = March 18, 2011 3:12:48.000 pm)

The following 8 16-bit values are ADC samples of the heart waveform

## H. Sensor Type 7

This sensor band contains:

- EDA – electrodermal activity sensor
- 3-axis accelerometer
- Ambient temperature sensor
- Ambient humidity sensor
- Skin temperature

Sample data packet:

* 0007 7F 0000012EC986A580 0FFF 0EBD 0EE5 0384 015F 0E9D FFFF FFFF 7C <CR> <LF>

PACKET HEADER SENSOR DATA

Packet Parsing:

* = start character (asterisk)

0007 = Packet Type/Format (indicates formatting of sensor data)

7F = packet counter (this is increments continuously)

0000012EC986A580 = Timestamp in milliseconds since January 1, 1970 (this one happens to be = March 18, 2011 3:12:48.000 pm)

0FFF = Accelerometer x-axis

0EBD = Accelerometer y-axis

0EE5 = Accelerometer z-axis

0384 = skin temperature (analog)

015F = $EDA_P$

0E9D = $EDA_{BIAS}$

FFFF = Ambient temperature (digital)
Example: Temperature = 0x09EF which is 29.47 C

FFFF = Ambient humidity
Example: Humidity = 0x024E which is 12.88%RH

7C = Additive checksum of packet mod 256

## I. Sensor Type 8 (draft)

This sensor band contains:

- Total ambient light level (lux)
- Infrared light level
- Red light level
- Green light level
- Blue light level
- 3-axis accelerometer
- Ambient temperature
- Sound level

Sample data packet:

* 0007 7F 0000012EC986A580 0FFF 0EBD 0EE5 0384 015F 0E9D FFFF FFFF 7C <CR> <LF>

PACKET HEADER SENSOR DATA

Packet Parsing:

* = start character (asterisk)

0007 = Packet Type/Format (indicates formatting of sensor data)

7F = packet counter (this is increments continuously)

0000012EC986A580 = Timestamp in milliseconds since January 1, 1970 (this one happens to be = March 18, 2011 3:12:48.000 pm)

0FFF = Total visible light

0EBD = Infrared light

0EE5 = Red light level

6/6/2013

0FFF = Blue light level

0EBD = Green light level

0FFF = Accelerometer x-axis

0EBD = Accelerometer y-axis

0EE5 = Accelerometer z-axis

FFFF = Ambient temperature
Example: Temperature = 0x09EF which is 29.47 C

FFFF = Ambient humidity
Example: Humidity = 0x024E which is 12.88%RH

FFFF = Ambient sound level
Example: sound level = 0x024E

7C = Additive checksum of packet mod 256

# V. Sensor Data Calculations

This section describes how to interpret and convert the raw byte values to actual biosensor parameters.

## A. EDA:

$EDA_{BIAS}$ voltage (value is approx ODA0 when not touching the skin)

$EDA_{P}$ voltage (value is approx 0DA0 when not touching the skin)

You need both of these signals to calculate the absolute EDA.

Use this formula:

$$TOTAL\ EDA = K*[(EDA_{BIAS}-EDA_{P})/(4096-EDA_{BIAS})]$$

the units for EDA are *conductance*, which is measured in mho (inverse ohm, otherwise known as siemens)

K is a calibration factor to get the right units (usually a K value between 1 and 5 is a good starting point to try) the larger the electrodes the smaller the K.

<u>To properly calibrate the sensor, you should place a 100K Ohm resistor across the terminals and make sure that you measure 10 micro-siemens.</u>

When relaxed, a typical value should be 0.5-5, depending on the indivudual. When you get nervous and your palms get sweaty, the values can rise to approximately 10. For people with autism or using medication, the values can be higher.

Here is an example showing how to calculate EDA.

Here are a few sample packets when there is nothing touching the contacts:

*00007F0000012EC986A5800FFF0EBD0EE5038407FF07FBFFFFFFFF
*00007F0000012EC986A5800FFF0EBD0EE5038408010 7FBFFFFFFFF
*00007F0000012EC986A5800FFF0EBD0EE5038408000 7FBFFFFFFFF
*00007F0000012EC986A5800FFF0EBD0EE503840800 0800FFFFFFFF

Here are a few sample packets when a 100K resistor is placed across the contacts:

*00007F0000012EC986A5800FFF0EBD0EE50384015F0E9DFFFFFFFF
*00007F0000012EC986A5800FFF0EBD0EE50384015D0E9AFFFFFFFF

*00007F0000012EC986A5800FFF0EBD0EE5038401600E9CFFFFFFFF
*00007F0000012EC986A5800FFF0EBD0EE50384015F0E9BFFFFFFFF

For example, using the last data packet above, you would get this:

$EDA_{Phasic}$ = &H015F = 351

$EDA_{BIAS}$= &H0E9B = 3739

TOTAL EDA = (3739-351)/(4096-3739) = 9.544

Using a calibration factor of K=1.05,
would give the correct EDA = 10 microseimens

When writing software, use a float variable, since the decimals are important.

## B. Analog Temperature:

In order to interpret the analog temperature data, you must first know whether you are using a first-generation or second-generation Ashametrics device. Second generation Ashametrics devices include Lifeband 2.0

### 1. <u>First-generation Lifeband devices</u>

On first-generation Ashametrics devices, the temperature sensors are purely analog (as opposed to digital) and used an analog temperature sensor chip (LM60). In this case, the data can be interpreted using the format below:

Here is a sample data packet showing the temperature field highlighted:

*00007F0000012EC986A5800FFF0EBD0EE50384015D0E9AFFFFFFFF

&H0384 = 900

From the LM60 data sheet, here is the formula:

T (in Celsius) = (V-0.424)/.00625

To start, first convert the A/D reading to a voltage.
(As you know, 0FFF = 4096 = 2.7V (approx) )

(900/4096) *2.7V = 0.5933 Volts

It might be easier to work in millivolts: 593.3 millivolts

If V is in millivolts, then:

$T = (593.3-424)/6.25 = 27.1$ degrees Celsius = 80.7 degrees F (approx)

## 2. Second –generation Devices (e.g. Lifeband 2.0)

On the newer Ashametrics Lifeband devices, the sensor band actually contains two temperature sensors – one digital and one analog. The Digital sensor is used to monitor the **ambient temperature** (see section below), and the analog sensor is designed to monitor small changes in **skin temperature**.

Why did Ashametrics design it this way? Because the small analog sensor is smaller and more sensitive to small changes in temperature than the digital temperature sensor. Using the 12-bit ADC value of the Ashametrics device, the analog sensor thus has better precision than the digital sensor, although the accuracy is less than the digital sensor. Since there are two sensors, the digital sensor reading can be used to calibrate the analog sensor.

To interpret the reading from the analog temperature sensor (skin temperature) on the second generation devices (e.g. LifeBand 2.0), the following table can be used. A polynomial approximation to these values can also be used.

Data is shown below for -40C to 150C degrees

| A/D | HEX | Temperature (C) |
|---|---|---|
| 995 | 3E3 | -40.27 |
| 994 | 3E2 | -39.33 |
| 993 | 3E1 | -38.41 |
| 992 | 3E0 | -37.52 |
| 991 | 3DF | -36.66 |
| 990 | 3DE | -35.82 |
| 989 | 3DD | -34.99 |
| 988 | 3DC | -34.19 |
| 987 | 3DB | -33.41 |
| 986 | 3DA | -32.64 |
| 985 | 3D9 | -31.89 |
| 984 | 3D8 | -31.16 |
| 983 | 3D7 | -30.44 |
| 982 | 3D6 | -29.74 |
| 981 | 3D5 | -29.05 |
| 980 | 3D4 | -28.37 |
| 979 | 3D3 | -27.71 |
| 978 | 3D2 | -27.06 |
| 977 | 3D1 | -26.42 |
| 976 | 3D0 | -25.79 |
| 975 | 3CF | -25.18 |
| 974 | 3CE | -24.57 |
| 973 | 3CD | -23.97 |
| 972 | 3CC | -23.39 |
| 971 | 3CB | -22.81 |
| 970 | 3CA | -22.24 |
| 969 | 3C9 | -21.68 |

6/6/2013

968 3C8 -21.13
967 3C7 -20.59
966 3C6 -20.05
965 3C5 -19.52
964 3C4 -19.00
963 3C3 -18.49
962 3C2 -17.98
961 3C1 -17.48
960 3C0 -16.98
959 3BF -16.50
958 3BE -16.02
957 3BD -15.54
956 3BC -15.07
955 3BB -14.60
954 3BA -14.15
953 3B9 -13.69
952 3B8 -13.24
951 3B7 -12.80
950 3B6 -12.36
949 3B5 -11.92
948 3B4 -11.49
947 3B3 -11.07
946 3B2 -10.65
945 3B1 -10.23
944 3B0 -9.82
943 3AF -9.41
942 3AE -9.01
941 3AD -8.61
940 3AC -8.21
939 3AB -7.82
938 3AA -7.43
937 3A9 -7.04
936 3A8 -6.66
935 3A7 -6.28
934 3A6 -5.90
933 3A5 -5.53
932 3A4 -5.16
931 3A3 -4.79
930 3A2 -4.43
929 3A1 -4.07
928 3A0 -3.71
927 39F -3.36
926 39E -3.01
925 39D -2.66
924 39C -2.31
923 39B -1.97
922 39A -1.63
921 399 -1.29
920 398 -0.95
919 397 -0.62
918 396 -0.29

6/6/2013

917 395 0.04
916 394 0.37
915 393 0.69
914 392 1.02
913 391 1.34
912 390 1.66
911 38F 1.97
910 38E 2.28
909 38D 2.60
908 38C 2.91
907 38B 3.21
906 38A 3.52
905 389 3.82
904 388 4.13
903 387 4.43
902 386 4.72
901 385 5.02
900 384 5.32
899 383 5.61
898 382 5.90
897 381 6.19
896 380 6.48
895 37F 6.76
894 37E 7.05
893 37D 7.33
892 37C 7.61
891 37B 7.89
890 37A 8.17
889 379 8.45
888 378 8.73
887 377 9.00
886 376 9.27
885 375 9.54
884 374 9.81
883 373 10.08
882 372 10.35
881 371 10.62
880 370 10.88
879 36F 11.15
878 36E 11.41
877 36D 11.67
876 36C 11.93
875 36B 12.19
874 36A 12.44
873 369 12.70
872 368 12.96
871 367 13.21
870 366 13.46
869 365 13.71
868 364 13.96
867 363 14.21

6/6/2013

866 362 14.46
865 361 14.71
864 360 14.96
863 35F 15.20
862 35E 15.45
861 35D 15.69
860 35C 15.93
859 35B 16.17
858 35A 16.41
857 359 16.65
856 358 16.89
855 357 17.13
854 356 17.36
853 355 17.60
852 354 17.83
851 353 18.07
850 352 18.30
849 351 18.53
848 350 18.76
847 34F 19.00
846 34E 19.22
845 34D 19.45
844 34C 19.68
843 34B 19.91
842 34A 20.13
841 349 20.36
840 348 20.58
839 347 20.81
838 346 21.03
837 345 21.25
836 344 21.48
835 343 21.70
834 342 21.92
833 341 22.14
832 340 22.36
831 33F 22.57
830 33E 22.79
829 33D 23.01
828 33C 23.22
827 33B 23.44
826 33A 23.65
825 339 23.87
824 338 24.08
823 337 24.29
822 336 24.51
821 335 24.72
820 334 24.93
819 333 25.14
818 332 25.35
817 331 25.56
816 330 25.77

6/6/2013

815 32F 25.97
814 32E 26.18
813 32D 26.39
812 32C 26.59
811 32B 26.80
810 32A 27.00
809 329 27.21
808 328 27.41
807 327 27.61
806 326 27.82
805 325 28.02
804 324 28.22
803 323 28.42
802 322 28.62
801 321 28.82
800 320 29.02
799 31F 29.22
798 31E 29.42
797 31D 29.62
796 31C 29.82
795 31B 30.01
794 31A 30.21
793 319 30.41
792 318 30.60
791 317 30.80
790 316 30.99
789 315 31.19
788 314 31.38
787 313 31.57
786 312 31.77
785 311 31.96
784 310 32.15
783 30F 32.34
782 30E 32.53
781 30D 32.73
780 30C 32.92
779 30B 33.11
778 30A 33.30
777 309 33.49
776 308 33.67
775 307 33.86
774 306 34.05
773 305 34.24
772 304 34.43
771 303 34.61
770 302 34.80
769 301 34.99
768 300 35.17
767 2FF 35.36
766 2FE 35.54
765 2FD 35.73

6/6/2013

764 2FC 35.91
763 2FB 36.10
762 2FA 36.28
761 2F9 36.46
760 2F8 36.65
759 2F7 36.83
758 2F6 37.01
757 2F5 37.19
756 2F4 37.37
755 2F3 37.56
754 2F2 37.74
753 2F1 37.92
752 2F0 38.10
751 2EF 38.28
750 2EE 38.46
749 2ED 38.64
748 2EC 38.82
747 2EB 39.00
746 2EA 39.17
745 2E9 39.35
744 2E8 39.53
743 2E7 39.71
742 2E6 39.89
741 2E5 40.06
740 2E4 40.24
739 2E3 40.42
738 2E2 40.59
737 2E1 40.77
736 2E0 40.95
735 2DF 41.12
734 2DE 41.30
733 2DD 41.47
732 2DC 41.65
731 2DB 41.82
730 2DA 41.99
729 2D9 42.17
728 2D8 42.34
727 2D7 42.52
726 2D6 42.69
725 2D5 42.86
724 2D4 43.04
723 2D3 43.21
722 2D2 43.38
721 2D1 43.55
720 2D0 43.72
719 2CF 43.90
718 2CE 44.07
717 2CD 44.24
716 2CC 44.41
715 2CB 44.58
714 2CA 44.75

6/6/2013

713 2C9 44.92
712 2C8 45.09
711 2C7 45.26
710 2C6 45.43
709 2C5 45.60
708 2C4 45.77
707 2C3 45.94
706 2C2 46.11
705 2C1 46.28
704 2C0 46.45
703 2BF 46.61
702 2BE 46.78
701 2BD 46.95
700 2BC 47.12
699 2BB 47.29
698 2BA 47.45
697 2B9 47.62
696 2B8 47.79
695 2B7 47.95
694 2B6 48.12
693 2B5 48.29
692 2B4 48.45
691 2B3 48.62
690 2B2 48.79
689 2B1 48.95
688 2B0 49.12
687 2AF 49.28
686 2AE 49.45
685 2AD 49.62
684 2AC 49.78
683 2AB 49.95
682 2AA 50.11
681 2A9 50.27
680 2A8 50.44
679 2A7 50.60
678 2A6 50.77
677 2A5 50.93
676 2A4 51.10
675 2A3 51.26
674 2A2 51.42
673 2A1 51.59
672 2A0 51.75
671 29F 51.91
670 29E 52.08
669 29D 52.24
668 29C 52.40
667 29B 52.57
666 29A 52.73
665 299 52.89
664 298 53.05
663 297 53.22

6/6/2013

662 296 53.38
661 295 53.54
660 294 53.70
659 293 53.86
658 292 54.03
657 291 54.19
656 290 54.35
655 28F 54.51
654 28E 54.67
653 28D 54.83
652 28C 54.99
651 28B 55.16
650 28A 55.32
649 289 55.48
648 288 55.64
647 287 55.80
646 286 55.96
645 285 56.12
644 284 56.28
643 283 56.44
642 282 56.60
641 281 56.76
640 280 56.92
639 27F 57.08
638 27E 57.24
637 27D 57.40
636 27C 57.56
635 27B 57.72
634 27A 57.88
633 279 58.04
632 278 58.20
631 277 58.36
630 276 58.52
629 275 58.68
628 274 58.84
627 273 59.00
626 272 59.15
625 271 59.31
624 270 59.47
623 26F 59.63
622 26E 59.79
621 26D 59.95
620 26C 60.11
619 26B 60.27
618 26A 60.42
617 269 60.58
616 268 60.74
615 267 60.90
614 266 61.06
613 265 61.22
612 264 61.38

6/6/2013

611 263 61.53
610 262 61.69
609 261 61.85
608 260 62.01
607 25F 62.17
606 25E 62.32
605 25D 62.48
604 25C 62.64
603 25B 62.80
602 25A 62.96
601 259 63.11
600 258 63.27
599 257 63.43
598 256 63.59
597 255 63.75
596 254 63.90
595 253 64.06
594 252 64.22
593 251 64.38
592 250 64.54
591 24F 64.69
590 24E 64.85
589 24D 65.01
588 24C 65.17
587 24B 65.32
586 24A 65.48
585 249 65.64
584 248 65.80
583 247 65.95
582 246 66.11
581 245 66.27
580 244 66.43
579 243 66.58
578 242 66.74
577 241 66.90
576 240 67.06
575 23F 67.22
574 23E 67.37
573 23D 67.53
572 23C 67.69
571 23B 67.85
570 23A 68.00
569 239 68.16
568 238 68.32
567 237 68.48
566 236 68.63
565 235 68.79
564 234 68.95
563 233 69.11
562 232 69.27
561 231 69.42

6/6/2013

560 230 69.58
559 22F 69.74
558 22E 69.90
557 22D 70.06
556 22C 70.21
555 22B 70.37
554 22A 70.53
553 229 70.69
552 228 70.85
551 227 71.00
550 226 71.16
549 225 71.32
548 224 71.48
547 223 71.64
546 222 71.79
545 221 71.95
544 220 72.11
543 21F 72.27
542 21E 72.43
541 21D 72.59
540 21C 72.75
539 21B 72.90
538 21A 73.06
537 219 73.22
536 218 73.38
535 217 73.54
534 216 73.70
533 215 73.86
532 214 74.02
531 213 74.18
530 212 74.33
529 211 74.49
528 210 74.65
527 20F 74.81
526 20E 74.97
525 20D 75.13
524 20C 75.29
523 20B 75.45
522 20A 75.61
521 209 75.77
520 208 75.93
519 207 76.09
518 206 76.25
517 205 76.41
516 204 76.57
515 203 76.73
514 202 76.89
513 201 77.05
512 200 77.21
511 1FF 77.37
510 1FE 77.53

6/6/2013

509 1FD 77.69
508 1FC 77.85
507 1FB 78.01
506 1FA 78.17
505 1F9 78.34
504 1F8 78.50
503 1F7 78.66
502 1F6 78.82
501 1F5 78.98
500 1F4 79.14
499 1F3 79.30
498 1F2 79.47
497 1F1 79.63
496 1F0 79.79
495 1EF 79.95
494 1EE 80.11
493 1ED 80.28
492 1EC 80.44
491 1EB 80.60
490 1EA 80.76
489 1E9 80.93
488 1E8 81.09
487 1E7 81.25
486 1E6 81.41
485 1E5 81.58
484 1E4 81.74
483 1E3 81.90
482 1E2 82.07
481 1E1 82.23
480 1E0 82.39
479 1DF 82.56
478 1DE 82.72
477 1DD 82.89
476 1DC 83.05
475 1DB 83.22
474 1DA 83.38
473 1D9 83.54
472 1D8 83.71
471 1D7 83.87
470 1D6 84.04
469 1D5 84.20
468 1D4 84.37
467 1D3 84.54
466 1D2 84.70
465 1D1 84.87
464 1D0 85.03
463 1CF 85.20
462 1CE 85.37
461 1CD 85.53
460 1CC 85.70
459 1CB 85.86

6/6/2013

458 1CA 86.03
457 1C9 86.20
456 1C8 86.37
455 1C7 86.53
454 1C6 86.70
453 1C5 86.87
452 1C4 87.04
451 1C3 87.20
450 1C2 87.37
449 1C1 87.54
448 1C0 87.71
447 1BF 87.88
446 1BE 88.05
445 1BD 88.22
444 1BC 88.39
443 1BB 88.55
442 1BA 88.72
441 1B9 88.89
440 1B8 89.06
439 1B7 89.23
438 1B6 89.40
437 1B5 89.58
436 1B4 89.75
435 1B3 89.92
434 1B2 90.09
433 1B1 90.26
432 1B0 90.43
431 1AF 90.60
430 1AE 90.77
429 1AD 90.95
428 1AC 91.12
427 1AB 91.29
426 1AA 91.46
425 1A9 91.64
424 1A8 91.81
423 1A7 91.98
422 1A6 92.16
421 1A5 92.33
420 1A4 92.51
419 1A3 92.68
418 1A2 92.85
417 1A1 93.03
416 1A0 93.20
415 19F 93.38
414 19E 93.55
413 19D 93.73
412 19C 93.91
411 19B 94.08
410 19A 94.26
409 199 94.44
408 198 94.61

6/6/2013

407 197 94.79
406 196 94.97
405 195 95.14
404 194 95.32
403 193 95.50
402 192 95.68
401 191 95.86
400 190 96.04
399 18F 96.22
398 18E 96.40
397 18D 96.57
396 18C 96.75
395 18B 96.93
394 18A 97.12
393 189 97.30
392 188 97.48
391 187 97.66
390 186 97.84
389 185 98.02
388 184 98.20
387 183 98.39
386 182 98.57
385 181 98.75
384 180 98.94
383 17F 99.12
382 17E 99.30
381 17D 99.49
380 17C 99.67
379 17B 99.86
378 17A 100.04
377 179 100.23
376 178 100.41
375 177 100.60
374 176 100.79
373 175 100.97
372 174 101.16
371 173 101.35
370 172 101.54
369 171 101.72
368 170 101.91
367 16F 102.10
366 16E 102.29
365 16D 102.48
364 16C 102.67
363 16B 102.86
362 16A 103.05
361 169 103.24
360 168 103.43
359 167 103.62
358 166 103.81
357 165 104.01

6/6/2013

356 164 104.20
355 163 104.39
354 162 104.59
353 161 104.78
352 160 104.97
351 15F 105.17
350 15E 105.36
349 15D 105.56
348 15C 105.75
347 15B 105.95
346 15A 106.15
345 159 106.34
344 158 106.54
343 157 106.74
342 156 106.94
341 155 107.13
340 154 107.33
339 153 107.53
338 152 107.73
337 151 107.93
336 150 108.13
335 14F 108.33
334 14E 108.54
333 14D 108.74
332 14C 108.94
331 14B 109.14
330 14A 109.35
329 149 109.55
328 148 109.75
327 147 109.96
326 146 110.16
325 145 110.37
324 144 110.57
323 143 110.78
322 142 110.99
321 141 111.20
320 140 111.40
319 13F 111.61
318 13E 111.82
317 13D 112.03
316 13C 112.24
315 13B 112.45
314 13A 112.66
313 139 112.87
312 138 113.08
311 137 113.30
310 136 113.51
309 135 113.72
308 134 113.94
307 133 114.15
306 132 114.37

6/6/2013

305 131 114.58
304 130 114.80
303 12F 115.02
302 12E 115.23
301 12D 115.45
300 12C 115.67
299 12B 115.89
298 12A 116.11
297 129 116.33
296 128 116.55
295 127 116.77
294 126 116.99
293 125 117.21
292 124 117.44
291 123 117.66
290 122 117.89
289 121 118.11
288 120 118.34
287 11F 118.56
286 11E 118.79
285 11D 119.02
284 11C 119.25
283 11B 119.47
282 11A 119.70
281 119 119.93
280 118 120.17
279 117 120.40
278 116 120.63
277 115 120.86
276 114 121.10
275 113 121.33
274 112 121.57
273 111 121.80
272 110 122.04
271 10F 122.27
270 10E 122.51
269 10D 122.75
268 10C 122.99
267 10B 123.23
266 10A 123.47
265 109 123.71
264 108 123.96
263 107 124.20
262 106 124.44
261 105 124.69
260 104 124.93
259 103 125.18
258 102 125.43
257 101 125.68
256 100 125.93
255 FF 126.17

6/6/2013

254 FE 126.43
253 FD 126.68
252 FC 126.93
251 FB 127.18
250 FA 127.44
249 F9 127.69
248 F8 127.95
247 F7 128.20
246 F6 128.46
245 F5 128.72
244 F4 128.98
243 F3 129.24
242 F2 129.50
241 F1 129.76
240 F0 130.03
239 EF 130.29
238 EE 130.56
237 ED 130.82
236 EC 131.09
235 EB 131.36
234 EA 131.63
233 E9 131.90
232 E8 132.17
231 E7 132.44
230 E6 132.72
229 E5 132.99
228 E4 133.27
227 E3 133.54
226 E2 133.82
225 E1 134.10
224 E0 134.38
223 DF 134.66
222 DE 134.94
221 DD 135.23
220 DC 135.51
219 DB 135.80
218 DA 136.08
217 D9 136.37
216 D8 136.66
215 D7 136.95
214 D6 137.25
213 D5 137.54
212 D4 137.83
211 D3 138.13
210 D2 138.43
209 D1 138.72
208 D0 139.02
207 CF 139.33
206 CE 139.63
205 CD 139.93
204 CC 140.24

203 CB 140.54
202 CA 140.85
201 C9 141.16
200 C8 141.47
199 C7 141.79
198 C6 142.10
197 C5 142.41
196 C4 142.73
195 C3 143.05
194 C2 143.37
193 C1 143.69
192 C0 144.01
191 BF 144.34
190 BE 144.67
189 BD 144.99
188 BC 145.32
187 BB 145.66
186 BA 145.99
185 B9 146.32
184 B8 146.66
183 B7 147.00
182 B6 147.34
181 B5 147.68
180 B4 148.02
179 B3 148.37
178 B2 148.72
177 B1 149.07
176 B0 149.42
175 AF 149.77
174 AE 150.13

## C. Digital Temperature

Newer Ashametrics Devices (for example Lifeband 2.0), contain a digital temperature sensor for reading the ambient temperature, which does not require any calibration.

For the digital temperature data, the temperature is calculated as follows:

Temperature in Celsius = ((raw value)/32) – 50

## D. Relative Humidity

Certain Sensor bands also contain humidity sensors. The relative humidity can be calculated from the raw humidity data as follows:

Relative Humidity (%) = ((raw hum)/16) -24

## E. Battery Level:

The battery voltage is read from a register in the sensor band memory and is not included in the data packet. The battery level can be calculated using the following formula:

Voltage = 5 * (battery reading / 4096) * 2.7

## F. Accelerometer:

There are 3 accelerometer fields – one for each axis. Since the acceleration value can be negative (negative g's) an offset of 32768 is added to each value in order to keep the digital value positive. If the sensor band board is held with one axis parallel to the gravitational force, you will see that 2 of the accelerometer parameters are approximately 32768 (which means zero) and the other shows a reading of –g. This enables the accelerometer values to be calibrated. The value of acceleration in units of g's is given by the following formula:

$A_i$ (in units of g's) = ($A_i$ -32768)/250

## G. Skin Temperature

For those sensors which measure skin temperature, this is done with an external thermistor, which is an analog reading. For the specific thermistor used in the Ashametrics LifeBands, the table below can be used to convert the voltage reading to temperature.

# VI. Annotation and Markers:

Markers are used to annotate the data during a data collection session or experiment.

A Marker can be generated on the sensor band itself by briefly pressing the pushbutton on the sensor band. In order to disable accidental button presses, this feature can be disabled by changing the setting on the sensor band.

Markers can also be generated by pressing the special “marker” button on the Android phone software or pressing the space bar on the LifeBand PC software program.

Then the user generates a marker, the software will insert a special data packet into the data log file which contains the marker ID plus a time stamp.

# VII. Sensor Band Commands

When the mobile phone or PC is connected to an Ashametrics sensor band via Bluetooth or via USB COM port, bidirectional serial communication is available. In addition to receiving the incoming data packets from the sensor band, it is also possible to send commands to the sensor band to change specific settings or to view files. <u>It should also be noted that Bluetooth and USB communications **cannot** be used simultaneously; you must choose one or the other.</u>

If you wish to download data file from the sensor band, there is a special command that you must send which will stop data collection on the sensor band and let you browse and download the available files on the sensor band. (see "memory access mode" command described below)

The following is a list of available commands that can be sent to the sensor band over a serial data connection. Each command must be followed by a carriage return.

## A. Registers – what are they?

All of the general device settings are stored in the device memory in a set of variables called "registers." These settings are stored in non-volatile memory, which means that the values are not erased when power is turned off.

Registers hold a variety of information and settings. In computer science, this is often called the machine "state". For example, there is one register which is used to set the time delay between data sampling, and there is another register that holds the current real time clock value.

## B. How to Read and Write to Registers

In order to read a register value, the command **GET** is used. For example, to read the value of register #1, you would send the command "**GET 1**".

In order to change a register value, we use the command **SET**, which is generally followed by an argument. For example, the command "**SET 2 1**" will write the number 1 into Register 2.

Notice that there is a space between the word SET and the register number and any arguments that follow. Also note that a carriage return must be sent at the end of the line. This is indicated as **<CR>.**

## C. General Device Commands

### 1. <u>Read State Values</u>

The following command returns the values of all state registers:
STAT<CR>

## 2. Read Firmware Version

The following command returns the firmware version:

GET 0<CR>

Will return:
0203<CR>
OK<CR>

## 3. Set Device ID

This command is used to set the device ID to a specific 8-byte hex number. This is done by writing to register 5 twice. The first write will set the upper four bytes, the second write will set the lower four bytes

To set the ID to 0123456789ABCDEF:
SET 5 89ABCDEF<CR>
SET 5 01234567<CR>

To read back the ID:
GET 5<CR>

Will return:
0123456789ABCDEF<CR>
OK<CR>

## 4. Set Time

This command is used to set the real time clock. The value should be in four byte epoch time (representing the number of seconds since January 1, 1970).

Important Note: the sensor band keeps track of time in units of milliseconds. However, to set the time, the user can only specify the time in integer number of seconds. The milliseconds or fractions of a second are set to zero.

To set the time to March 29, 2011 5:23:29 PM:
SET 1 4D921591<CR>

(Remember that these numbers are in hexadecimal representation, so 15=F, 255 = FF, etc.)

To read back the time (one second later):
GET 1<CR>

Will return:

4D921592<CR>
OK<CR>

### 5. Enable/Disable Wireless Data Streaming

The following command is used to turn ON wireless data streaming:

SET 2 1<CR>

The following command is used to turn OFF wireless data streaming:

SET 2 0<CR>

### 6. Enable/Disable Data Logging

The following command is used to turn ON data logging and start recording data to the SD card:

SET 3 1<CR>

The following command is used to turn OFF data logging:

SET 3 0<CR>

### 7. Set Data Sampling Interval

The following command sets the data sampling interval:

SET 4 *N*<CR>
Where n represents the sampling interval (delay between samples) given by the following formula.

Sampling interval = $2^n$ * 125 milliseconds

Valid values for n are between 0 and 3 inclusive.

### 8. Read Battery Level

The following command returns the battery level:

GET 6<CR>

### 9. Set/Read Sensor Data Format

Depending on the application, some people prefer to use different data formats for the data being transmitted by the device. For example, the Ashametrics heart rate monitor device can transmit data as a heart waveform, to enable people to plot the actual heart waveform, or the heart monitor can be set to simply transmit the heart rate value and heart rate variability. Each of these are different “data formats” or “operating modes” that are available.

For LifeBands that monitor heart rate, and with firmware versions 1.17 and greater, it is possible to change the sensor packet format to be either sensor format 2, 3, or 5. Note that if a non-ECG band is set to sensor format 3 or 5, the heart beat data will not be valid. The following command will set a band to sensor format 5:

SET 8 5<CR>

### 10. <u>Set/Read Heartbeat Timeout</u>

When no valid heartbeat is detected within the heartbeat timeout, the instantaneous and average heartrate fields are set to 0. This timeout by default is 1500 ms, but can be changed by the user. The following command will set the heartbeat timeout to 3000ms (note that the value 3000 decimal must be coded to hexadecimal):

SET 9 BB8

## D. Power Settings

The sensor band can operate in several power modes. This feature is under development and only supported by some newer devices. Please contact Ashametrics for more information.

The power mode is set by the following command:

TBD

Where n is one of the following modes:

- Mode 0

For real time diagnostics, P0 can be used.
In this mode, the device will not go to sleep and will stream data continuously according to the specified sampling rate.

- Mode 1

For extreme power savings, P1 mode can be used. In this mode, the sensor band will go to sleep and will only broadcast (or log) sensor readings when it is woken up by an external interrupt signal. Every time the sensor band is woken up, it will then sample the data (or time) and then go back to sleep. The interrupt signal source can be selected using the interrupt source select command.

### 1. Interrupt Source Select Command

When the board is in mode P1, the board will remain asleep unless it is woken up by an external signal. You can choose which signal is used to wake up the band using this command.

TBD

Where n is one of the following values:

I0 – serial port wake up – this enables the sensor to be woken up by any incoming data signal on the serial data line.
Note: I0 is the default setting, and is always active. In other words, even if the interrupt source I2 is selected, for example, the serial port wake up is still active. Thus when I0 is set, this means that all other interrupt sources are disabled, except for the serial port interrupt.

I1 – This sets the heart rate sensor as the wake up signal. For every heart beat, the sensor will wake up, take a reading, and record a time stamp.

I2 – This sets the EDA signal as the wake up signal. When the EDA signal is above a value of 10 uS (settable in hardware), the board will wake up and take a reading and time stamp. This can be used, for example, to record every time someone has a stress event or to record the times of epileptic seizures.

I3 – this sets the accelerometer component Ax as the wake up signal. This can be used to count steps, for example, in a pedometer application or to record hand flapping (stereotopy) events in Autism.

(currently not implemented)

## E. PPG Commands

The Ashametrics PPG (photoplethysmography) heart monitor wrist band contains some additional commands that are used to control the LEDs of the device. This is a custom product. Please contact Ashametrics for further information.

### 1. Turning ON/OFF LEDs

TBD

The PPG circuit has two sets of LEDs: Red (~660nm) and Infrared (~900nm).

6/6/2013

For the PPG circuit, the different sets of LED's can be controlled with the following commands:

2. **Setting Brightness value of LEDs**

TBD

The sensor bands enables the ability to adjust the brightness of each set of LEDs with the following command

3. **Setting the frequency of the LED flashing**

The LED's used in the PPG circuit can be programmed to flash at a relatively high rate which is used by the circuit to enable synchronous detection of the PPG signal.
The frequency of the flashing can be controlled by the following commands

TBD

Where the argument n, is given in milliseconds
Sending a value of X will disable the flashing altogether.

# VIII. Downloading Data from your Ashametrics Device

Most Ashametrics devices contain an internal memory card (usually 2GB), which enables the sensor band to log/record data independently of the Bluetooth radio.

All Ashametrics devices also contain Bluetooth and can stream live data to an external Bluetooth device. However, for some applications, you may want to simply store data on the device itself and download the data afterwards.

The data files that have been recorded can be accessed wirelessly through the use of special Bluetooth commands that will let you browse and download all the data files from the sensor band. Some security features have been added to prevent surreptitious downloading of data.

On the device, the internal memory files can also be accessed via USB connection to a PC or via a live Bluetooth connection. On the older first-generation versions of the LifeBand, the memory card must be removed and connected to a PC through a standard memory card adapter.

Note that certain software applications (e.g. Ashamon) will use the memory card files instead of using a different file format generated on the mobile phone.

## 1. Enter/Exit Memory Access Mode

In order to access files on the device internal memory, the device first needs to be put into Memory Access Mode. In this mode, data collection is stopped, and memory access commands are valid. To enter this mode, use the following command.

SET 7 1<CR>

To exit out of this mode and return back to data collection, use the following command:

SET 7 0<CR>

## 2. Read Directories on the Memory Card

(You must be in “Memory Access mode” to use this command)

The files on the SD card are stored in a folder structure. Basic DOS type commands are used to access the files. In order to read the contents of the current folder, send the following command:

DIR<CR>

A listing of the folders and files will be returned.

## 3. Changing Directories on the Memory Card

(You must be in “Memory Access mode” to use this command)

To navigate through the directories, use the following command:

CD <folder name><CR>

Where <folder name> is one of the returned directories.

## 4. Fetching Files

(You must be in “Memory Access mode” to use this command)

To fetch a file, use the following command:

FETCH <file name><CR>

This will cause the entire contents of the file to be transmitted.

Alternatively, to retrieve the file in sections, use the same command with two additional arguments:

FETCH <file name> <start byte> <number of bytes><CR>

The <start byte> and <number of bytes> arguments should be in hexadecimal. The <start byte> specifies the starting byte in the file to begin retrieving from, and the <number of bytes> argument specifies how many bytes to fetch. For example:

FETCH 0.txt 20 40<CR>

Will begin fetching at byte number 32 decimal, and retrieve a total of 64 bytes decimal. This then would be followed up by

FETCH 0.txt 60 40<CR>

And so on, to eventually retrieve the entire file.

## 5. Deleting files and folders on the Memory Card

(You must be in “Memory Access mode” to use this command)

A file or directory can be erased with the following command:

6/6/2013

DEL <file or folder name><CR>

Only empty folders can be deleted.  If a folder still has files in it, it will not delete.

# IX. How to Read the Raw Ashametrics Data Files

All LifeBands contain an internal memory card (usually 2GB), which enables the sensor band to log/record data independently of the Bluetooth radio.

The data files that have been recorded can be accessed wirelessly through the use of special Bluetooth commands that will let you browse and download all the data files from the sensor band. Some security features have been added to prevent surreptitious downloading of data.

On the LifeBand, the internal memory files can also be accessed via USB connection to a PC. On very old versions of the LifeBand, the memory card must be removed and connected to a PC through a standard memory card adapter.

Note that certain software applications (e.g. Ashamon) will use the memory card files instead of using a different file format generated on the mobile phone.

## A. Parsing Sample Data Logger file (Type 5):

There are 3 main sections to each data file. The first section is the register output. This is a record of the state of all the internal registers at the time the data file was first created. Each line in this section is preceded by a '#' symbol, followed by the register number, then a colon, and then finally the register value in hexadecimal. The register numbers are defined in detail in the Sensor Command section, but as a brief summary:

**Register 0: Firmware Version** – this is the version of firmware that is currently programmed on the LifeBand. On newer Lifebands, this firmware is upgradable.

**Register 1: Device ID** – The Device ID is a user-programmable XXX-byte hexadecimal string that can be used to indicate the patient or subject ID.

**Register 2: Wireless Streaming Flag** – When this register is set to 0, the LifeBand does not broadcast packets over Bluetooth. When this register is nonzero, it broadcasts a packet at every sample interval.

**Register 3: Data Logging Flag** – When this register is set to 0, the LifeBand does not store packets on the internal SD memory card. When this register is nonzero, it stores packets on the internal SD memory card.

**Register 4: Sample Interval** – This register sets the sample rate. A value of zero corresponds to an 8 Hz sample rate, a one corresponds to a 4 Hz sample rate, a two corresponds to a 2 Hz sample rate, and a three or greater corresponds to a 1 Hz sample rate.

**Register 5: Local Time** – This is a hexadecimal timestamp in milliseconds since January 1, 1970 corresponding to the time at which the file was created.

**Register 6: Battery Level** – This is the current battery level in hexadecimal – use the formula in the sensor data calculations section to convert to voltage.

**Register 7: Memory Access Mode** – This register is used to set the LifeBand into memory access mode in order to allow the internal memory card to ba accessed via Bluetooth. Writing a value of 0 to this register will enter the memory access mode and disable data sampling. Once in memory access mode, the SD memory commands such as “CD” and “FETCH” can be used. A value of 0 in this register means it is memory access mode, a value of 1 means the band is in normal operating mode.

**Register 8: Sensor Format Type** – This register indicates the sensor type, as dictated in the Types of Sensor Bands section.

**Register 9: Heart beat detection interval** – This is the amount of time over which the heart beat detection algorithm will search for a heart beat. In the case of ECG, the heart beat is detected using the R-peak of the signal, and the sensor band records the time interval between successive R-intervals (i.e. the IBI parameters). The time interval is a 10 byte number and is stored in units of milliseconds. This register is irrelevant for sensor bands which do not contain a heart sensor.

More registers may be added later, following this same format.

Following the register values, the memory data file contains the raw data packets, one per line. These lines of data follow the format outlined in the Data Packet Parsing section of the datasheet for the given sensor band type, with one small difference. Each line of data that is transmitted over Bluetooth contains one additional byte at the end representing the checksum over the previous bytes of the packet. In the logged SD card data, there is no checksum byte.

Finally, the last section is the End of File marker. This will contain information about why the file ended – either due to a power down, the end of an hour of recording, or because the SD card was removed from the device.

## B. Data format

Each line of data recorded on the memory card follows the same format as the data packet structure that is transmitted wirelessly via Bluetooth. However, there are 2 important differences:

**1. <u>Start of recording header</u>**

When the recording is activated (data logging is turned ON), all the sensor band settings are written to the memory card. If you import the data from the memory card into Excel, you will notice that these lines of data being with the character "$", which indicates that these characters are not part of the sensor data.

**2. <u>End of recording header</u>**

When a recording is ended, there is another set of bytes that are written to the memory card. This set of bytes indicates the reason why the recording was stopped. There are several possible values:

- Recording was stopped because someone pulled out the memory card
- Recording was stopped because someone turned off the power
- Recording was stopped because the "Data Logging OFF"command was received.

Except for these two header fields, the rest of the data saved to the memory card should look identical to the data packet format that is transmitted wirelessly. Each line of data begins with an asterisk and ends with a carriage return character.

## C. Folder format on memory card

When the sensor band is turned ON, a new folder is automatically created. The folders are number sequentially, "iCalm0", "iCalm1", "iCalm2", etc.
(note: on newer sensor bands, the word iCalm might be replaced with Lifeband)

When recording is first started, a new text file will be written to the card, starting with filename = 0.txt
If the recording is stopped, then the next time recording starts, the new file name will be incremented (for example to 1.txt).

If the sensor band is set to record continuously for long periods of time, then every hour, the sensor band will close the data file and immediately create a new file with the name incremented.
For example, let's say that the current file being recorded is file name = 68.txt and the data collection is started at 9:36 pm.

Then if the sensor band is left ON, at the start of the next hour (10:00 pm), then the file 68.txt will be closed and a new file will be opened called 69.txt
At 11pm, the next file will be created, called "70.txt" etc.

The reasoning for this behavior is this feature will prevent the data files from becoming too large, so they could be more easily transmitted wirelessly.

<u>Important note:</u> if the time is NOT set, then the file will be written at every hour that is elapsed. (so for example if the sensor band recording was started at 9:36 pm, but the time on the sensor band was not set, then the band would continue writing to the same file (68.txt) until 10:36pm. At this time, the file 68.txt would be closed, and the sensor band would start writing data to a new file (69.txt).

<u>Time accuracy:</u> The LifeBand uses a 32 KHz crystal to synchronize its real-time clock and is accurate to 15 parts per million. Time accuracy may degrade when operating under extreme temperatures.

Note that every single line of data begins with an asterisk, and the first 2 bytes of data describe the type of sensor device that generated the data. This information is used by the data analysis software to properly parse and interpret the raw data file.

## D. Recognizing Marker Events in the Data File

As mentioned previously, markers are commonly used when conducting experiments as a way to mark specific events. If the a mobile phone application is used, the software will insert a special data packet into the data log file which contains the marker ID plus a time stamp.

Marker packets have a similar format as data packets from sensor bands, but the <u>sensor ID is given a special value that begins with "FF" (such as FF02, FF08, FFA5, etc.)</u>. Also, the sensor values in this marker data packet are set to zero.

Also, there can be multiple marker *types*: Marker1, Marker2, Marker3, etc…. Each marker type can be used to annotate a particular type of event or behavior.

## E. Sample Data Logger file from sensor band (Type 5):

```
#0: 0112
#1: 00000003
#2: 0001
#3: 0001
#4: 0001
#5: a000000000000001
#6: 0b2c
#7: 0001
#8: 0005
```

#9: 05DC


*0005000000000000000085680217ff180f203d1080c080c011b00fb
*00050100000000000008d4801f7ff180f003d3080b080b011b00fb
*00050200000000000009c8801e7ff180f203d3080c080c0114011d
*0005030000000000000ac9801e7ff180f103d3080c080e01130116
*0005040000000000000bbd80227ff080f003d4080d080f01130115
*0005050000000000000cb280227ff280f003d4080a080c01130115
*0005060000000000000db280207ff380f103d8080c080f01130115
*0005070000000000000ea680207ff180ef03d6080e080a011c0115
*0005080000000000000fa980207ff080ed03d3080d080c01120115
*000509000000000000109e801f7ff480ed03d50809080b01130114
*00050a000000000000119e80207ff180ef03d8080e080f011c0115
*00050b000000000000129280207ff180ef03d2080c080b011c0115
*00050c000000000000138880217ff080f103d2080b08090113 0115

6/6/2013

*0005380000000000003e8080207ff080f403d40809080901130117
*0005390000000000003f8180207ff180f303d3080b080c011b0117
*00053a0000000000004075801e7ff180ef03d5080d080c01130117
*00053b0000000000004176801f7ff280f003d30809080801140116
*00053c000000000000426a80207ff080f003d2080c080c01140116
#EOF DISK REMOVED