Vitalograph®

# Model 4000 Device

## Application Programming Interface (API)

# ISSUE CONTROL SHEET

| ISSUE | EFFECT DATE | CHANGE BY | DESCRIPTION OF CHANGE |
|---|---|---|---|
| 1 | 27/05/09 | JOK | Released from revision 1.04 |
| 2 | 27/10/2009 | MD | Updated to include current Bluetooth settings. |
| 3 | 30/04/2010 | MD | Added extra details to Test Criteria section.<br>Removed the Reset Occurred messages from asma-1 and Lung-Monitor |
| 4 | 07 Jan 2014 | Mike O Dea | Added measurement unit values to tables.<br>Added the following note to COPD-6 specific messages (Automatic Single Test Data )<br>“If the bad blow symbol (!) is displayed on the COPD-6 device, then the good test flag will be 0 to indicate that the test has failed QA.”<br>Added the following note to asma-1 specific messages (Automatic Single Test Data )<br>If the bad blow symbol (!) is displayed on the Asma-1 device, then the good test flag will be 1 to indicate that the test has failed QA.<br>Added the following note to View Memory asma-1<br>For example, the value for data field "Bad Test Best PEF" is 1 if the best test PEF result comes from a bad test .The value for data field "Bad Test Best PEF" is 0 if the best test PEF result comes from a good test.<br>Text correction - Automatic Single Test Data (Lung Monitor)<br>“*The bad test flag shall be a 1 if the test has not failed QA it shall be 0 otherwise” was replaced with *The good test flag shall be a 0 if the test has not failed QA it shall be 1 otherwise."<br>(If the bad blow symbol (!) is displayed on the lung monitor device, then the good test flag will be 1 to indicate that the test has failed QA)<br>Text Correction - View Memory (Lung Monitor)<br>"*The good test flag shall be a 1 if the test has not failed QA it shall be 0 otherwise" was replaced with "*The bad test flag shall be a 1 if the test has failed QA it shall be 0 otherwise."<br>For example, the value for data field "Bad Test FEV" is 1 if the best test FEV1 result comes from a bad test<br>The value for data field "Bad Test FEV1" is 0 if the best test FEV1 result comes from a good test. |
| 5 | 20/03/2014 | M. Donohue | Added new sections for Lung-Monitor Bluetooth 4.0 device<br>• Added Bluetooth 4.0 Operation description to Section 3<br>• Added Section 10 Lung-Monitor BTLE specific messages |

## Table of Contents

# 1. Purpose & Scope

The purpose of this document is to define the serial communications protocol adopted by Vitalograph for the exchange of general spirometry data between the Model 4000 communication devices.
This API covers all model 4000 Devices.

# 2. Link Characteristics

## Data Character Format

Baud Rate : 19200 Baud (Bits per second).
Start Bits : 1.
Stop Bits : 1.
Data Bits : 8.
Parity Bits : None.

## Link Level

Communications will always be in a fixed master-slave relationship. This means that all communications will be initiated by the master device, and the slave will respond as appropriate, so there is no need for any link establishment protocol.

If a message from the master requires a response message from the slave, it should be transmitted immediately after it acknowledges the request message. It is the responsibility of the master not to initiate any further communications until the response has been received, unless a time-out (5 seconds) occurs.

The data content of messages will always be in printable ASCII characters. This avoids the necessity for data transparency, as no control characters can appear in a message.

Any text fields within a message will be transmitted left-justified and padded with spaces on the right if shorter than the allotted field length.

Any numeric fields within a message will be transmitted right-justified and may be padded with ASCII zeros on the left if shorter than the allotted field length.

## Remote Mode

To initiate communication with a Model 4000 Device it must first be entered into remote mode. There are three methods of entering the device into this mode:

- When powering on the device hold the UP button.
- Press the enter button when the Report Icon is on screen.

- On the asma-1 and Lung-Monitor hold the UP button for 3 seconds on the blow now screen.

If the device is powered on in remote mode then it shall stay in this state for 1 minute. All other methods enter the device into remote mode for 2 seconds. While in remote mode the device will not respond to any button presses.
**The device shall only respond to messages while in remote mode.**

## Device Identifier

Each variant of the Model 4000 has a specific Device Identifier Character these characters are:

- copd-6 = **D**(44 Hex)
- asma-1 = **C**(43 Hex)
- lung-monitor = **F**(46 Hex)
- lung-monitor BTLE = **G**(47 Hex)

# 3. Bluetooth Operation

## Bluetooth 2.0 Operation

The Bluetooth Model 4000 operates using the Bluetooth Serial Port Profile (SPP). The device will connect to one SPP connection at a time, further connection requests will be denied. Once a connection has been made communication is performed in the same manner as that of the Serial/USB Model 4000.

### Device Bluetooth Local Name

Each Model 4000 device is configured with a unique Bluetooth Local name, which takes the form of one of the following:

| | |
|---|---|
| ASMA_XXXX | (asma-1 device) |
| COPD_XXXX | (copd-6 device) |
| LUNG_XXXX | (lung-monitor device) |

Where X are the last four digits of the device serial number.

### Device Bluetooth PIN Code

The Model 4000 devices have a Bluetooth 2.0 PIN code of:

8158

### Device Connection

The device shall be connectable from power on however remote mode must be entered before communication can begin.

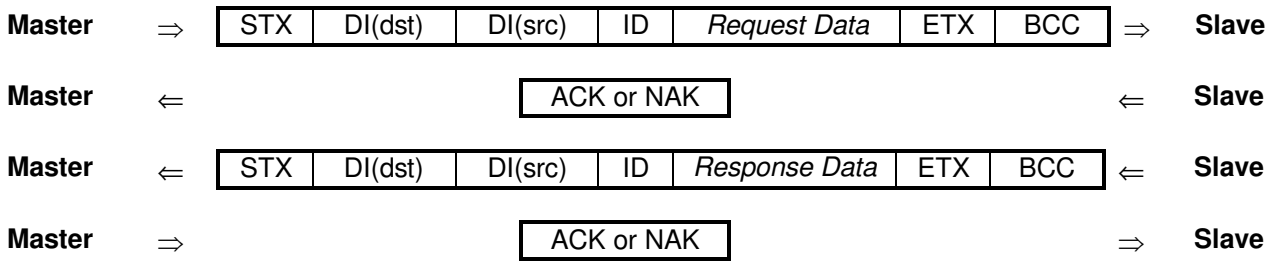
## Bluetooth 4.0 Operation

The BTLE variant of the Model 4000 uses a proprietary Bluetooth Low Energy Profile for bidirectional serial communication. Vitalograph provide Objective C source code and documentation for handling the Bluetooth connection and data transfer for iOS devices.

Documentation for this source code is provided separately in HTML appledoc format. Once a connection has been made communication is performed in the same manner as that of other Model 4000 variants.

# Message Formats

The general format for all messages will be:




The following symbology is applied.

STX = Start of Text character (02 Hex)
DI(dst) = 1 ASCII character device identifier - Destination (see below)
DI(src) = 1 ASCII character device identifier - Source (see below)
ID = 2 ASCII character message identifier (see below)
Data = Transmitted data in ASCII (length depends on message type)
ETX = End of Text character (03 Hex)
BCC = Checksum - Exclusive OR of all other bytes from STX to ETX inclusive.
ACK = Positive Acknowledgement character (06 Hex)
NAK = Negative Acknowledgement character (15 Hex)

- The receiver will ignore all inputs until STX is received.
- There will not be any time-out check between bytes in a message - if a transmitted message is not completed, the receiver will simply not take any action.
- The receiver will respond with NAK if the transmitted checksum did not match the calculated checksum, otherwise the receiver will respond with ACK.
- On receipt of NAK or if no response is received within 1 second, the transmitter will repeat the entire message up to a maximum of 3 times, whereupon it will abandon all attempts at communication and display an error message for the user.
- There may be any number of response messages, and in some cases none at all. The number to be expected is defined for each particular message.
- There may be some exceptions to the above message format, which will be defined in the device-specific protocol specification.

# 4. Test Criteria

## Test Session

A test session can be started in two ways on the device:
• When the device is powered on a new session is started.
• If at any point the On/Off button is pressed during use of the device a new test session is started.
Each test session on the device is stored as a single View Memory record on the device.

## Best Test

The best values are calculated as the highest values in a session, e.g. the best FEV1 is the highest FEV1 from the session.

On the COPD-6 device, which stores the best 3 tests in a session, these are the tests with the highest FEV1, FEV6 sum.

## Automatic Single Test Data

Each device shall transmit all test parameters automatically after a test has been performed. However these parameters may not be saved to the view memory record if they do not rank in the best test for that session.

## Lung Age (COPD-6)

The Lung Age on the COPD-6 is calculated as follows:

For Children (Ages 1 – 20)
Lung Age (Male) = ((LN(FEV1)+1.2933-(1.2669*Height(m)))/(0.0174*Height(m)))
Lung Age (Female) = (((LN(FEV1)+1.5974-1.5016*(Height(m)))/(0.0119*Height(m))))

Reference: SpirXpert Spirometry CD, Philip H Quanjer & Henk Stam et al., March 12, 2000.

For Adults (Ages 20+)
Lung Age (Male) = (2.87 x Height (in inches)) – (31.25 x FEV1) – 39.375
Lung Age (Female) = (3.56 x Height (in inches)) – (40 x FEV1) – 77.28

Reference: Normal Values and Evaluation of Forced End-Expiratory Flow, James F. Morris, Arthur Koski and John D. Breese, American Review of Respiratory Disease, Vol. 111, 1975.

# 5. Communications Sequence

Communication with the Model 4000 devices and message sequences can be broken down to the following procedures:

## Device Identification Procedure

When initiating communication with the device the **Device Identification** message should be transmitted first to verify the correct device is connected. Further identification can be performed using the **Get ID** message, which returns the device ID number.

## Date / Time Procedure

The current device time can be read using the **Get Time** message. If the time is incorrect it can be updated using the **Set Time** message.

## View Memory Procedure

Test Session Data can be read from the device using the **View Memory** message.

## Configuration Procedure

If needed a number of configurations can be performed on the device these include:

- Resetting of Device Defaults using **Reset Defaults**.
- Configuration of zones and personal best values using **Set Zones** and **Set Personal Best**.
- Clearing of Test Session memory using **Clear Memory**.

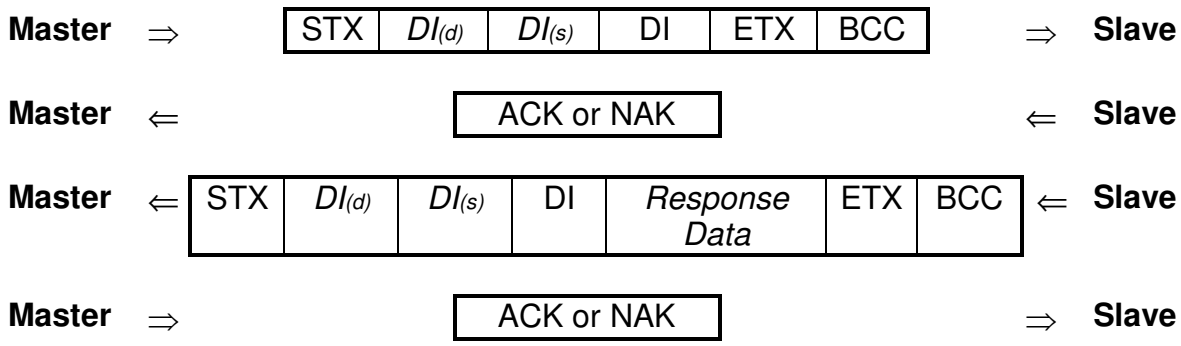
## Exit Remote Procedure

When communications is complete the **Exit remote** message should be sent to conclude communications.
It is recommended to perform the Procedures in the order they are listed above.

# 6. Model 4000 Generic Messages

## Device Identification Message

Reads device identification data from the slave. It is recommended to begin communication with this message.




There is no request data, and the response data consists of:

| # Chars | Data | Content |
|---|---|---|
| 1 | Device Identifier | e.g. D |
| 1 | Hardware Revision Letter | e.g. _ |
| 3 | Software Revision Number | e.g. 100 (= rev 1.00) |

Example of request message :
ASCII: $^{S}_{X}$ **D V D I** $^{E}_{X}$ $^{B}C_{C}$

Example of response message :
ASCII: $^{S}_{X}$ **V D D I D _ 1 0 0** $^{E}_{X}$ $^{B}C_{C}$

## Clear Memory Message

Clears the memory on the device

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | CM | ETX | BCC | ⇒ **Slave** |
| **Master** | ⇐ | ACK or NAK | | | | | | ⇐ **Slave** |

There is no request or response data.

Example of request message :
ASCII: $^{S}_{X}$ D V C M $^{E}_{X}$ $^{B}C_{C}$

## Set Zones

Allows the user to set the 3 zones on the device.

| **Master** ⇒ | STX | *DI(d)* | *DI(s)* | SZ | *Data* | ETX | BCC | ⇒ **Slave** |
|---|---|---|---|---|---|---|---|---|

| **Master** ⇐ | ACK or NAK | ⇐ **Slave** |
|---|---|---|

There is no response data and the request data consists of:

| # Chars | Data | Example |
|---|---|---|
| 3 | Green Zone* | e.g. 080 (%) |
| 3 | Yellow Zone** | e.g. 050 (%) |
| 3 | Orange Zone*** | e.g. 030 (%) |

*For the Green Zone to be valid it must be larger than the Yellow and Orange Zone values transmitted.

**For the Yellow Zone to be valid it must be larger than the Orange Zone and less than the Green Zone values transmitted.

***For the Orange Zone to be valid it must be less than the Yellow Zone and less than the Green Zone values transmitted.

If any transmitted zone value is incorrect the zones shall not be set.

Example of request message :
ASCII: $^{S}_{X}$ **D V S Z 0 8 0 0 5 0 0 3 0** $^{E}_{X}$ $^{B}C_{C}$

## Get Zones

Allows the user to view the 3 zones on the device

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | GZ | ETX | BCC | ⇒ **Slave** |
| **Master** | ⇐ | ACK or NAK | | | | | | ⇐ **Slave** |
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | GZ | *Response Data* | ETX | BCC ⇐ **Slave** |
| **Master** | ⇒ | ACK or NAK | | | | | | ⇒ **Slave** |

There is no request data, and the response data consists of:

| # Chars | Data | Example |
|---|---|---|
| 3 | Green Zone | e.g. 080 (%) |
| 3 | Yellow Zone | e.g. 050 (%) |
| 3 | Orange Zone | e.g. 030 (%) |

Example of request message :
ASCII: $^{S}_{X}$ **D V G Z** $^{E}_{X}$ $^{B}C_{C}$

Example of response message :
ASCII: $^{S}_{X}$ **V D G Z 0 8 0 0 5 0 0 3 0** $^{E}_{X}$ $^{B}C_{C}$

## Get Battery Level

Sends the current battery level in bits to the PC

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | GB | ETX | BCC | ⇒ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇐ | ACK or NAK | ⇐ **Slave** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | GB | *Response Data* | ETX | BCC | ⇐ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇒ | ACK or NAK | ⇒ **Slave** |

There is no request data, and the response data consists of:

| # Chars | Data | Example |
|---|---|---|
| 4 | Battery Volts (Bits) * | 1023 |

*Vbat = 3.3V x ( (Received Battery Voltage in Bits) / 1024 )

Example of request message :
ASCII: $^{S}_{X}$ **D V G B** $^{E}_{X}$ $^{B}C_{C}$

Example of response message :
ASCII: $^{S}_{X}$ **V D G B 1 0 2 3** $^{E}_{X}$ $^{B}C_{C}$

## Exit Remote Mode

Allows the user to exit the communications mode.

| **Master** ⇒ | STX | *DI(d)* | *DI(s)* | X | R | ETX | BCC | ⇒ **Slave** |
|---|---|---|---|---|---|---|---|---|

| **Master** ⇐ | ACK or NAK | ⇐ **Slave** |
|---|---|---|

There is no request or response data.

Example of request message :
ASCII: $^{S}_{X}$ **D V X R** $^{E}_{X}$ $^{B}C_{C}$

## Reset Defaults

Allows the user to reset the setting back to the default factory settings

| **Master** ⇒ | STX | *DI(d)* | *DI(s)* | RD | ETX | BCC | ⇒ **Slave** |
|---|---|---|---|---|---|---|---|

| **Master** ⇐ | ACK or NAK | ⇐ **Slave** |
|---|---|---|

There is no request or response data.

Example of request message :
ASCII: $^{S}_{X}$ **D V R D** $^{E}_{X}$ $^{B}C_{C}$

## Get Time

Sends the time on the device to the PC

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | GT | ETX | BCC | ⇒ | **Slave** |
| **Master** | ⇐ | ACK or NAK | | | | | | ⇐ | **Slave** |
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | GT | *Response Data* | ETX BCC | ⇐ | **Slave** |
| **Master** | ⇒ | ACK or NAK | | | | | | ⇒ | **Slave** |

There is no request data, and the response data consists of:

| # Chars | Data | Example |
|---|---|---|
| 2 | Year | e.g. 08 (2008) |
| 2 | Month | e.g. 07 |
| 2 | Day | e.g. 31 |
| 2 | Hour | 12 |
| 2 | Minute | 30 |
| 2 | Second | 27 |

Example of request message :
ASCII: $^{S}_{X}$ **D V G T** $^{E}_{X}$ $^{B}C_{C}$

Example of response message :
ASCII: $^{S}_{X}$ **V D G T 0 8 0 7 3 1 1 2 3 0 2 7** $^{E}_{X}$ $^{B}C_{C}$

## Set Time

Sends the time on the PC to the device

| **Master** ⇒ | STX | *DI(d)* | *DI(s)* | ST | *Request Data* | ETX | BCC | ⇒ **Slave** |
|---|---|---|---|---|---|---|---|---|

| **Master** ⇐ | ACK or NAK | ⇐ **Slave** |
|---|---|---|

There is no response data and the request data consists of:

| # Chars | Data | Example |
|---|---|---|
| 2 | Year | e.g. 08 (2008) |
| 2 | Month | e.g. 07 |
| 2 | Day | e.g. 31 |
| 2 | Hour | 12 |
| 2 | Minute | 30 |
| 2 | Second | 27 |

Example of request message :

ASCII: $^{S}_{X}$ **D V S T 0 8 0 7 3 1 1 2 3 0 2 7** $^{E}_{X}$ $^{B}C_{C}$

## Get ID

Gets the ID from the device

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | ID | ETX | BCC | ⇒ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇐ | ACK or NAK | ⇐ **Slave** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | ID | *Response Data* | ETX | BCC | ⇐ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇒ | ACK or NAK | ⇒ **Slave** |

The Data section of the transmitted is explained in the following table:

| #Chars | Data | Content |
|---|---|---|
| 10 | Device ID | e.g. 0210356960 |

Example of request message :
ASCII: $^{S}_{X}$ **D V I D** $^{E}_{X}$ $^{B}C_{C}$

Example of response message :
ASCII: $^{S}_{X}$ **V D I D 0 2 1 0 3 5 6 9 6 0** $^{E}_{X}$ $^{B}C_{C}$

## Shutdown Message

This message is automatically transmitted when the device powers down.

**Master** ⇒ | STX | *DI(s)* | PD | ETX | BCC | ⇒ **Slave**

There is no request or response data.

Example of message:

ASCII: $^{S}_{X}$ **D P D** $^{E}_{X}$ $^{B}C_{C}$

# 7. COPD-6 Specific Messages

## Automatic Single Test Data (COPD-6)

The transfer of single test data is also automatically done after each blow is performed. The data is structured as follows:

| **Master** ⇐ | $^{S}X$ | *DI(s)* | *TD* | Data | $^{E}X$ | BCC | ⇐ **Slave** |
|---|---|---|---|---|---|---|---|

$^{S}X$ = Start of text character (02 Hex)
D = 1 ASCII character device identifier
TD = 2 ASCII character message identifier
Data = Transmitted data in ASCII (see below)
$^{E}X$ = End of Text character (03 Hex)
BCC = Checksum – Exclusive OR of all other bytes from $^{S}X$ to $^{E}X$

The Data section of the transmitted is explained in the following table:

| #Chars | Data | Content |
|---|---|---|
| 10 | Device ID | e.g. 1234567VIT |
| 1 | Gender | e.g. M |
| 2 | Age | e.g. 50 |
| 3 | Height* | e.g. 175 (cm) |
| 3 | Regression Set | e.g. 001 |
| 3 | Weight** | e.g. 078 (Kg) |
| 3 | FEV1 Predicted | e.g. 359 (3.59Litres) |
| 3 | FEV1 | e.g. 322 (3.22Litres) |
| 3 | FEV6 Predicted | e.g. 444 (4.44Litres) |
| 3 | FEV6 | e.g. 326 (3.26Litres) |
| 3 | FEV1/FEV6 Predicted | e.g. 078 (Ratio 0.78) |
| 3 | FEV1/FEV6 | e.g. 099 (Ratio 0.99) |
| 3 | Lung Age | e.g. 058 (years) |
| 2 | Year | e.g. 13 (2013) |
| 2 | Month | e.g. 10 |
| 2 | Day | e.g. 25 |
| 2 | Hour | e.g. 12 |
| 2 | Minute | e.g. 30 |
| 2 | Second | e.g. 30 |
| 1 | Good Test Flag*** | e.g. 1 |
| 3 | SW Version Number | e.g. 102 |

*The units of Height shall be inches if the transmitted value is less than 100 otherwise the units are in centimetres.

**The units of weight are Kilograms.

COPD-6 Specific Messages

***The good test flag shall be a 1 if the test has not failed QA it shall be 0 otherwise.
(If the bad blow symbol (!) is displayed on the COPD-6 device, then the good test flag will be 0 to indicate that the test has failed QA)

## View Memory (COPD-6)

Allows the user to view the tests currently stored in memory

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | VM | ETX | BCC | ⇒ **Slave** |
| **Master** | ⇐ | ACK or NAK | | | | | | ⇐ **Slave** |
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | VM | *Response Data* | ETX | BCC ⇐ **Slave** |
| **Master** | ⇒ | ACK or NAK | | | | | | ⇒ **Slave** |

There is no request data and the response data consists of:

| #Chars | Data | Content |
|---|---|---|
| 1 | Gender | e.g. M |
| 2 | Age | e.g. 50 |
| 3 | Height | e.g. 175 |
| 3 | Regression Set | e.g. 1 |
| 3 | Weight | e.g. 078 (Kg) |
| 10 | Device ID | e.g. 1234567VIT |
| 2 | #Tests | e.g. 05 |
| 2 | #GoodTests | e.g. 03 |
| 3 | FEV1 within | e.g. 006 (0.06Litres) |
| 3 | FEV6 within | e.g. 003 (0.03Litres) |
| 3 | FEV1 Predicted | e.g. 359 (3.59Litres) |
| 3 | FEV1 Best1 | e.g. 322 (3.22Litres) |
| 3 | FEV1 Best2 | e.g. 316 (3.16Litres) |
| 3 | FEV1 Best3 | e.g. 301 (3.01Litres) |
| 3 | FEV1 Measured Best | e.g. 322 (3.22Litres) |
| 3 | FEV1% Pred | e.g. 090 (90%) |
| 3 | FEV6 Predicted | e.g. 444 (4.44Litres) |
| 3 | FEV6 Best1 | e.g. 326 (3.26Litres) |
| 3 | FEV6 Best2 | e.g. 323 (3.23Litres) |
| 3 | FEV6 Best3 | e.g. 309 (3.09Litres) |
| 3 | FEV6 Measured Best | e.g. 326 (3.26Litres) |
| 3 | FEV6% Pred | e.g. 073 (73%) |
| 3 | FEV1/FEV6 Predicted | e.g. 078 (Ratio 0.78) |
| 3 | FEV1/FEV6 Best1 | e.g. 099 (Ratio 0.99) |
| 3 | FEV1/FEV6 Best2 | e.g. 098 (Ratio 0.98) |
| 3 | FEV1/FEV6 Best3 | e.g. 097 (Ratio 0.97) |
| 3 | FEV1/FEV6 Measured Best | e.g. 099 (Ratio 0.99) |
| 3 | FEV1/FEV6% Pred | e.g. 127 (127%) |

| | | |
|---|---|---|
| 3 | Green Zone | e.g. 080 (%) |
| 3 | Yellow Zone | e.g. 050 (%) |
| 3 | Orange Zone | e.g. 030 (%) |
| 3 | Lung Age | e.g. 58 (years) |
| 3 | SW Version Number | e.g. 102 |
| 3 | Firmware Number | e.g. 913 |
| 2 | Year | e.g. 13 (2013) |
| 2 | Month | e.g. 10 |
| 2 | Day | e.g. 25 |
| 2 | Hour | e.g. 12 |
| 2 | Minute | e.g. 30 |
| 2 | Second | e.g. 30 |
| 1 | Session Time Updated Flag* | e.g. 1 |

* Field is no longer used

Example of request message :
ASCII: $^{S}_{X}$ **D V V M** $^{E}_{X}$ $^{B}C_{C}$

# 8. asma-1 Specific Messages

## Automatic Single Test Data (asma-1)

The asma-1 firmware includes the transmission of single test data. The transfer of data is automatically done after each blow is performed. The data is structured as follows:

| **Master** ⇐ | $^{S}X$ | *DI(s)* | TD | Data | $^{E}X$ | BCC | ⇐ **Slave** |
|---|---|---|---|---|---|---|---|

$^{S}X$ = Start of text character (02 Hex)
C = 1 ASCII character device identifier
TD = 2 ASCII character message identifier
Data = Transmitted data in ASCII (see below)
$^{E}X$ = End of Text character (03 Hex)
BCC = Checksum – Exclusive OR of all other bytes from $^{S}X$ to $^{E}X$

The Data section of the transmitted is explained in the following table:

| #Chars | Data | Content |
|---|---|---|
| 10 | Device ID | e.g. 1234567VIT |
| 3 | FEV1 | e.g. 327 (3.27Litres) |
| 3 | PEF | e.g. 480 (480 litres/min) |
| 3 | FEV1 Personal Best | e.g. 380 (3.80Litres) |
| 3 | PEF Personal Best | e.g. 560 (560 litres/min) |
| 3 | FEV1% | e.g. 086 (86%) |
| 3 | PEF% | e.g. 086 (86%) |
| 3 | Green Zone | e.g. 080 (%) |
| 3 | Yellow Zone | e.g. 050 (%) |
| 3 | Orange Zone | e.g. 030 (%) |
| 2 | Year | e.g. 13 (2013) |
| 2 | Month | e.g. 10 |
| 2 | Day | e.g. 25 |
| 2 | Hour | e.g. 12 |
| 2 | Minute | e.g. 30 |
| 2 | Second | e.g. 30 |
| 1 | Good Test* | e.g. 1 |
| 3 | SW Number | e.g. 912 |

*The good test flag shall be a 0 if the test has not failed QA it shall be 1 otherwise.
(If the bad blow symbol (!) is displayed on the asma-1 device, then the good test flag will be 1 to indicate that the test has failed QA)

## Get Personal Best (asma-1)

Allows the user to view the personal best settings on the device

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | PB | ETX | BCC | ⇒ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇐ | ACK or NAK | ⇐ **Slave** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | PB | *Response Data* | ETX | BCC | ⇐ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇒ | ACK or NAK | ⇒ **Slave** |

There is no request data, and the response data consists of:

| # Chars | Data | Example |
|---|---|---|
| 3 | FEV1 Personal Best | 310 (3.10Litres) |
| 3 | PEF Personal Best | 420 (420 litres/min) |

Example of request message :
ASCII: $^{S}_{X}$ **C V P B** $^{E}_{X}$ $^{B}C_{C}$

Example of response message :
ASCII: $^{S}_{X}$ **V C P B 3 1 0 4 2 0** $^{E}_{X}$ $^{B}C_{C}$

## Set Personal Best (asma-1)

Allows the user to set the personal best settings on the device

| **Master** ⇒ | STX | *DI(d)* | *DI(s)* | SP | *Data* | ETX | BCC | ⇒ **Slave** |
|---|---|---|---|---|---|---|---|---|

| **Master** ⇐ | ACK or NAK | ⇐ **Slave** |
|---|---|---|

There is no response data and the request data consists of:

| # Chars | Data | Example |
|---|---|---|
| 3 | FEV1 Personal Best | 310 (3.10Litres) |
| 3 | PEF Personal Best | 420 (420 litres/min) |

Example of request message :
ASCII: $^{S}_{X}$ **C V S P 3 1 0 4 2 0** $^{E}_{X}$ $^{B}C_{C}$

## View Memory (asma-1)

Allows the user to view the data stored on the device (up to 600 test sessions).

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | VM | ETX | BCC | ⇒ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇐ | ACK or NAK | ⇐ **Slave** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | VM | *Response Data* | ETX | BCC | ⇐ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇒ | ACK or NAK | ⇒ **Slave** |

The final response message will be followed by a test consisting of all asterisk characters.

The Data section of the transmitted is explained in the following table:

| #Chars | Data | Content |
|---|---|---|
| 10 | Device ID | e.g. 1234567VIT |
| 3 | Best FEV1 | e.g. 327 (3.27Litres) |
| 3 | Best PEF | e.g. 480 (480 litres/min) |
| 3 | FEV1 Personal Best | e.g. 380 (3.80Litres) |
| 3 | PEF Personal Best | e.g. 560 (560 litres/min) |
| 3 | Best FEV1% | e.g. 086 (86%) |
| 3 | Best PEF% | e.g. 086 (86%) |
| 3 | Green Zone | e.g. 080 (%) |
| 3 | Yellow Zone | e.g. 050 (%) |
| 3 | Orange Zone | e.g. 030 (%) |
| 2 | Session Year | e.g. 13 (2013) |
| 2 | Session Month | e.g. 10 |
| 2 | Session Day | e.g. 25 |
| 2 | Session Hour | e.g. 12 |
| 2 | Session Minute | e.g. 30 |
| 2 | Session Second | e.g. 30 |
| 1 | Bad Test Best PEF* | e.g. 1 |
| 1 | Bad Test Best FEV1* | e.g. 1 |
| 3 | SW Version Number | e.g. 104 |
| 3 | SW Number | e.g. 912 |
| 2 | Number of Blows | e.g. 22 |
| 2 | Number of Good Blows | e.g. 10 |

Asma-1 Specific Messages

*The bad test flag shall be a 1 if the test has failed QA it shall be 0 otherwise.

For example, the value for  data field "Bad Test Best PEF" is 1 if the best test PEF result comes from a bad test

The value for data field "Bad Test Best PEF" is 0 if the best test PEF result comes from a good test.

Example of request message :
ASCII: $^{S}_{X}$ **C V V M** $^{E}_{X}$ $^{B}C_{C}$

# 9. Lung Monitor Specific Messages

## Automatic Single Test Data (Lung Monitor)

The Lung Monitor firmware includes the transmission of single test data. The transfer of data is automatically done after each blow is performed. The data is structured as follows:

| **Master** ⇐ | $^{S}X$ | *DI(s)* | *TD* | Data | $^{E}X$ | BCC | ⇐ **Slave** |
|---|---|---|---|---|---|---|---|

$^{S}X$ = Start of text character (02 Hex)
F = 1 ASCII character device identifier
TD = 2 ASCII character message identifier
Data = Transmitted data in ASCII (see below)
$^{E}X$ = End of Text character (03 Hex)
BCC = Checksum – Exclusive OR of all other bytes from $^{S}X$ to $^{E}X$

The Data section of the transmitted is explained in the following table:

| #Chars | Data | Content |
|---|---|---|
| 10 | Device ID | e.g. 1234567VIT |
| 3 | FEV1 | e.g. 327 (3.27Litres) |
| 3 | FEV6 | e.g. 480 (480 litres/min) |
| 3 | FEV1/FEV6 | e.g. 068 (Ratio 0.68) |
| 3 | FEF2575 | e.g. 395 (3.95 litres/sec) |
| 3 | FEV1 Personal Best | e.g. 380 (3.80Litres) |
| 3 | FEV1% | e.g. 086 (86%) |
| 3 | Green Zone | e.g. 080 (%) |
| 3 | Yellow Zone | e.g. 050 (%) |
| 3 | Orange Zone | e.g. 030 (%) |
| 2 | Year | e.g. 13 (2013) |
| 2 | Month | e.g. 10 |
| 2 | Day | e.g. 25 |
| 2 | Hour | e.g. 12 |
| 2 | Minute | e.g. 30 |
| 2 | Second | e.g. 30 |
| 1 | Good Test* | e.g. 0 |
| 3 | SW Number | e.g. 912 |

*The good test flag shall be a 0 if the test has not failed QA it shall be 1 otherwise."
(If the bad blow symbol (!) is displayed on the lung monitor device, then the good test flag will be 1 to indicate that the test has failed QA)

## Get Personal Best (Lung Monitor)

Allows the user to view the personal best settings on the device

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | PB | ETX | BCC | ⇒ | **Slave** |
| **Master** | ⇐ | | ACK or NAK | | | | | ⇐ | **Slave** |
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | PB | *Response Data* | ETX | BCC | ⇐ **Slave** |
| **Master** | ⇒ | | ACK or NAK | | | | | ⇒ | **Slave** |

There is no request data, and the response data consists of:

| # Chars | Data | Example |
|---|---|---|
| 3 | FEV1 Personal Best | 310 (3.10Litres) |

Example of request message :
ASCII: $^{S}_{X}$ **F V P B** $^{E}_{X}$ $^{B}C_{C}$

Example of response message :
ASCII: $^{S}_{X}$ **V F P B 3 1 0** $^{E}_{X}$ $^{B}C_{C}$

## Set Personal Best (Lung Monitor)

Allows the user to set the personal best settings on the device

| **Master** ⇒ | STX | *DI(d)* | *DI(s)* | SP | *Data* | ETX | BCC | ⇒ **Slave** |
|---|---|---|---|---|---|---|---|---|

| **Master** ⇐ | ACK or NAK | ⇐ **Slave** |
|---|---|---|

There is no response data and the request data consists of:

| # Chars | Data | Example |
|---|---|---|
| 3 | FEV1 Personal Best | 310 (3.10Litres) |

Example of request message :
ASCII: $^{S}_{X}$ **F V S P 3 1 0** $^{E}_{X}$ $^{B}C_{C}$

## View Memory (Lung Monitor)

Allows the user to view the data stored on the device (up to 200 test sessions).

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | VM | ETX | BCC | ⇒ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇐ | ACK or NAK | ⇐ **Slave** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | VM | *Response Data* | ETX | BCC | ⇐ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇒ | ACK or NAK | ⇒ **Slave** |

The final response message will be followed by a test consisting of all asterisk characters.

The Data section of the transmitted is explained in the following table:

| #Chars | Data | Content |
|---|---|---|
| 10 | Device ID | e.g. 1234567VIT |
| 3 | Best FEV1 | e.g. 327 (3.27Litres) |
| 3 | Best FEV6 | e.g. 480 (480 litres/min) |
| 3 | Best FEV1/FEV6 | e.g. 068 (Ratio 0.68) |
| 3 | FEV1 Personal Best | e.g. 380 (3.80Litres) |
| 3 | Best FEF 25 -75 | e.g. 395 (3.95 litres/sec) |
| 3 | Best FEV1% | e.g. 086 (86%) |
| 3 | Green Zone | e.g. 080 (%) |
| 3 | Yellow Zone | e.g. 050 (%) |
| 3 | Orange Zone | e.g. 030 (%) |
| 2 | Year | e.g. 13 (2013) |
| 2 | Month | e.g. 10 |
| 2 | Day | e.g. 25 |
| 2 | Hour | e.g. 12 |
| 2 | Minute | e.g. 30 |
| 2 | Second | e.g. 30 |
| 1 | Bad Test FEV1* | e.g. 1 |
| 1 | Bad Test FEV6* | e.g. 1 |
| 1 | Bad Test FEF 25-75* | e.g. 1 |
| 3 | SW Version Number | e.g. 100 |
| 3 | SW Number | e.g. 915 |
| 2 | Number of Blows | e.g. 22 |
| 2 | Number of Good Blows | e.g. 10 |

Lung Monitor Specific Messages

*The bad test flag shall be a 1 if the test has failed QA it shall be 0 otherwise.

For example, the value for data field "Bad Test FEV" is 1 if the best test FEV1 result comes from a bad test
The value for data field "Bad Test FEV1" is 0 if the best test FEV1 result comes from a good test.

# 10. Lung Monitor BTLE Specific Messages

## Automatic Single Test Data (Lung Monitor BTLE)

The Lung Monitor BTLE firmware includes the transmission of single test data. The transfer of data is automatically done after each blow is performed. The data is structured as follows:

| **Master** ⇐ | $^{S}X$ | *DI(s)* | *TD* | Data | $^{E}X$ | BCC | ⇐ **Slave** |
|---|---|---|---|---|---|---|---|

$^{S}X$ = Start of text character (02 Hex)
G = 1 ASCII character device identifier
TD = 2 ASCII character message identifier
Data = Transmitted data in ASCII (see below)
$^{E}X$ = End of Text character (03 Hex)
BCC = Checksum – Exclusive OR of all other bytes from $^{S}X$ to $^{E}X$

The Data section of the transmitted is explained in the following table:

| #Chars | Data | Content |
|---|---|---|
| 10 | Device ID | e.g. 1234567VIT |
| 3 | PEF | e.g. 480 (480 litres/min) |
| 3 | FEV0.75 | e.g. 289 (2.89Litres) |
| 3 | FEV1 | e.g. 327 (3.27Litres) |
| 3 | FEV10 | e.g. 480 (4.80Litres) |
| 3 | FEV1/FEV10 | e.g. 068 (Ratio 0.68) |
| 3 | FEF2575 | e.g. 395 (3.95 litres/sec) |
| 3 | FEV1 Personal Best | e.g. 380 (3.80Litres) |
| 3 | PEF Personal Best | e.g. 480 (480 litres/min) |
| 3 | FEV1% | e.g. 086 (86%) |
| 3 | PEF% | e.g. 100 (100%) |
| 3 | Green Zone | e.g. 080 (%) |
| 3 | Yellow Zone | e.g. 050 (%) |
| 3 | Orange Zone | e.g. 030 (%) |
| 2 | Year | e.g. 13 (2013) |
| 2 | Month | e.g. 10 |
| 2 | Day | e.g. 25 |
| 2 | Hour | e.g. 12 |
| 2 | Minute | e.g. 30 |
| 2 | Second | e.g. 30 |
| 1 | Good Test* | e.g. 0 |
| 3 | SW Number | e.g. 912 |

*The good test flag shall be a 0 if the test has not failed QA it shall be 1 otherwise."
(If the bad blow symbol (!) is displayed on the lung monitor device, then the good test flag will be 1 to indicate that the test has failed QA)

## Get Personal Best (Lung Monitor BTLE)

Allows the user to view the personal best settings on the device

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | PB | ETX | BCC | ⇒ | **Slave** |
| **Master** | ⇐ | | ACK or NAK | | | | | ⇐ | **Slave** |
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | PB | *Response Data* | ETX | BCC | ⇐ **Slave** |
| **Master** | ⇒ | | ACK or NAK | | | | | ⇒ | **Slave** |

There is no request data, and the response data consists of:

| # Chars | Data | Example |
|---|---|---|
| 3 | PEF Personal Best | 480 (480Litres/min) |
| 3 | FEV1 Personal Best | 310 (3.10Litres) |

## Set Personal Best (Lung Monitor BTLE)

Allows the user to set the personal best settings on the device

**Master** ⇒ | STX | *DI(d)* | *DI(s)* | SP | *Data* | ETX | BCC | ⇒ **Slave**

**Master** ⇐ | ACK or NAK | ⇐ **Slave**

There is no response data and the request data consists of:

| # Chars | Data | Example |
|---|---|---|
| 3 | PEF Personal Best | 480 (480Litres/min) |
| 3 | FEV1 Personal Best | 310 (3.10Litres) |

## View Memory (Lung Monitor BTLE)

Allows the user to view the data stored on the device (up to 600 test sessions).

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Master** | ⇒ | STX | *DI(d)* | *DI(s)* | VM | ETX | BCC | ⇒ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇐ | ACK or NAK | ⇐ **Slave** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Master** | ⇐ | STX | *DI(d)* | *DI(s)* | VM | *Response Data* | ETX | BCC | ⇐ **Slave** |

| | | | |
|---|---|---|---|
| **Master** | ⇒ | ACK or NAK | ⇒ **Slave** |

The final response message will be followed by a test consisting of all asterisk characters.

The Data section of the transmitted is explained in the following table:

| #Chars | Data | Content |
|---|---|---|
| 10 | Device ID | e.g. 1234567VIT |
| 3 | Best PEF | e.g. 480 (480Litres/min) |
| 3 | Best FEV0.75 | e.g. 299 (2.99Litres) |
| 3 | Best FEV1 | e.g. 327 (3.27Litres) |
| 3 | Best FEV10 | e.g. 480 (480 litres/min) |
| 3 | Best FEV1/FEV10 | e.g. 068 (Ratio 0.68) |
| 3 | Best FEF2575 | e.g. 357 (3.57 litres/sec) |
| 3 | FEV1 Personal Best | e.g. 380 (3.80Litres) |
| 3 | PEF Personal Best | e.g. 395 (395 litres/min) |
| 3 | Best FEV1% | e.g. 086 (86%) |
| 3 | Best PEF% | e.g. 086 (86%) |
| 3 | Green Zone | e.g. 080 (%) |
| 3 | Yellow Zone | e.g. 050 (%) |
| 3 | Orange Zone | e.g. 030 (%) |
| 2 | Year | e.g. 13 (2013) |
| 2 | Month | e.g. 10 |
| 2 | Day | e.g. 25 |
| 2 | Hour | e.g. 12 |
| 2 | Minute | e.g. 30 |
| 2 | Second | e.g. 30 |
| 1 | Bad Test PEF* | e.g. 1 |
| 1 | Bad Test FEV0.75* | e.g. 1 |
| 1 | Bad Test FEV1* | e.g. 1 |
| 1 | Bad Test FEV10* | e.g. 1 |
| 1 | Bad Test FEF 25-75* | e.g. 1 |
| 3 | SW Version Number | e.g. 100 |

| | | |
|---|---|---|
| 3 | SW Number | e.g. 961 |
| 2 | Number of Blows | e.g. 22 |
| 2 | Number of Good Blows | e.g. 10 |

Lung Monitor Specific Messages

*The bad test flag shall be a 1 if the test has failed QA it shall be 0 otherwise.

For example, the value for  data field "Bad Test FEV" is 1 if the best test FEV1 result comes from a bad test
The value for data field "Bad Test FEV1" is 0 if the best test FEV1 result comes from a good test.