

SAMI Record Format - SAMI/AFT CO₂, pH and Alk

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Records are stored and downloaded as binary bytes. They are sent over the serial port as they are generated as hexadecimal - i.e. as ASCII characters representing hexadecimal numbers.

For 'E' and earlier (or 'E-') revision boards, all records sent over the serial link are preceded by '*'.

For 'J' and later (or 'J+') revision boards, records are contained in packets which are prefaced using the following scheme:

- :0 - loader record
- :1 - data/control/error record
- :3 - SAMI properties record
- :4 - recording status (returned from 'J' poll by client)
- :5 - command response record
- :6 - progress for slow executions

In either case (* or :#) a one byte hash of the SAMI name and calibration (a non-unique identifier). The client software uses the above to recognize the start of a record, and discards them. Following that is the actual record which has following features:

All records begin with a **length** byte, the length count includes the length and **checksum** bytes. A record can be up to 255 bytes long. The second byte is **record type**. The next 4 bytes are the **time**, seconds since Jan 1 1904 GMT (totalSeconds)

Example:

This string is the beginning of a SAMI-pH record sent over the serial port:

*BFE70AC8EF9AF8... (E- board) or :1BFE70AC8EF9AF8... (J+ board)

The '*' indicates a record is to follow or the ':1' indicates a data record to follow. The 'BF' represents a hash of the SAMI name and calibration (a unique identifier). 'E7' is hexadecimal for 231 and is the length of the record. '0A' (10 decimal) indicates this is a pH record. 'C8EF9648' is the date/time in seconds and translates to October 28, 2010 21:26 GMT.

All records end with a 1 byte **checksum** - the low byte of the sum of the bytes including the length and type. This is used for error checking of the transmission.

Status Packets/Pings

Both types of boards send out a status packet. E- boards send packet whenever RTS is high on serial port. J+ boards send packet in response to a timed 'J' command by the client.. See other documentation for structure of these packets.

Record types

There are 3 main types of records: **Control/Error** and **Data**. Control records type byte (second byte above) are 128 -255 (x80-xFF). Data records are 0-127 (x00-x7F).

Control records that a user may commonly encounter include:

- 128 (x80) - Launch - the program has started executing, but not necessarily measurements, which can be delayed.
- 129 (x81) - Start - the measurement sequence has started.
- 131 (x83) - Good shutdown
- 133 (x85) - Handshake turned on (RTS high)
- 134 (x86) - primary battery restored
- 135 (x87) - User stopped recording with Q command

Error Records

- 192 (xC0) - Primary battery low in record (pump on) extra word Battery read
- 193 (xC1) - Primary battery low in Blank (Valve & pump on)
- 194 (xC2) - Process queue overflow - no primary battery?
- 195(xC3) - Process stopped no primary battery
- 196 (xC4) - Driver not found
- 197 (xC5) - Driver is off - enable bits for driver are 00

Data records - SAMI-CO2

The CO2 instrument has two types of records, the regular measurement (type 4) and the blank measurement records (type 5). They are structured as above, with length (39 bytes), type (4 or 5), time and a trailing checksum.

Here is an example of a type 4 (SAMI-CO2 E- Board) record:

```
*5B2704C8EF9FC90FE606400FE8063C0FE30674640B1B1F0FE6065A0FE907
F0FE306A60CDE0FFF3B
```

A J+ board record would look the same except the '*' would be replaced by ':1'.

Note that the length of this string is 81 characters, while above we said that the length of the record is 39 bytes. The reason for this is that each byte in hex is represented by 2 characters (x00 to xFF) and we throw away the first three characters, as mentioned above. So $81 - 3 = 78 = 2 * 39$.

In a data record the fields following time will represent measured quantities usually as 2 bytes. In the case of the type 4 records shown above, the 28 bytes after the time are all measurements of light, followed by a thermistor reading, and a battery reading and the checksum.

Bytes Description

1	Length
1	Type
4	Time
28	14 sets of light measurements (2 bytes ea.)
2	Battery
2	Thermistor
1	<u>Checksum</u>
39	Total bytes in type 4 record

The type 5 or 'blank' record is identical to the type 4 record except for the type byte. It is treated differently by the client software since it represents a baseline measurement of the optical throughput.

The SAMI optical read on the firmware level reads into a buffer as follows (2 bytes each):

Raw_Light = dark_ref, dark_sig, 434_ref, 434_sig, 620_ref, 620_sig (12 bytes)

In the record above, the 28 bytes consist of these 12 bytes measured at start of measurement and at end of measurement. (The LEDs flash multiple times and are averaged.)

The SAMI sums and averages the 434 and 620 signal to reference ratio, dark adjusted - these 2 ratios are the main optical measurement values used to calibrate the instrument:

$$R434 = \text{Sum}(434_sig - \text{dark_sig}) / \text{Sum}(434_ref - \text{dark_ref})$$

$$R620 = \text{Sum}(620_sig - \text{dark_sig}) / \text{Sum}(620_ref - \text{dark_ref})$$

So the 28 bytes of light measurements are

Raw_Light1, R434, R620, Raw_Light2

Data records - SAMI-pH (also iSAMI-pH and πSAMI-pH)

Data records for the pH instrument are similar to above. The string will be twice as long plus three (465 characters).

<i>Bytes</i>	<i>Description</i>
1	Length
1	Type
4	Time
2	Starting thermistor
32	4 sets of 'blank' light measurements (8 bytes ea.)

184	23 sets of 'reagent' light measurements (8 bytes ea.)
2	internal thermistor on i/πSAMI-pH (not used on regular SAMI)
2	Battery
2	Thermistor
<u>1</u>	<u>Checksum</u>
231	Total bytes in type 10 record

On pH instruments, dark measurements are subtracted from the signal/reference before storage to reduce size of the record. Each set of blank/reagent light measurements is in following order (8 bytes total, 27 sets in above)

434 nm reference (dark adjusted) - 2 bytes
434 nm signal (dark adjusted) - 2 bytes
578 nm reference (dark adjusted) - 2 bytes
578 nm signal (dark adjusted) - 2 bytes

Data records - SAMI-alk

The SAMI-alk creates multiple records for each measurement. Type 6, 12 are for seawater, while types 7,13 are for standards.

Type 6,7 are the starting record types

<i>Bytes</i>	<i>Description</i>
1	Length
1	Type
4	Time
1	start thermistor
240	light/pH measurements
<u>1</u>	<u>checksum</u>
248	total bytes

Type 12,13 are continuation records. As of firmware 1031 there are 2 of these.

<i>Bytes</i>	<i>Description</i>
1	Length
1	Type
4	Time
240	light/pH measurements
1	battery
1	final therm
<u>1</u>	<u>checksum</u>
249	total bytes

The 'light/pH' measurements consist of 2 bytes each as follows, where sig/ref readings are already dark adjusted:

434_Sig, 434_Ref, 575_Sig, 575_Ref, Calc_pH

The calculated pH is multiple by 100 before encoding.

Data records - Generic external (0-5V device)

The SAMI can read up to three 0-5V inputs. (Devices 1-3) They are very simple, containing just the information of which device is being read in the 'type' byte and 2 bytes encoding the A/D converted voltage. Type x10 (16), x20 (32), x30 (48) records refer to devices 1, 2, 3 respectively

<i>Bytes</i>	<i>Description</i>
1	Length
1	Type
4	Time
2	Voltage (A/D converted)
<u>1</u>	<u>Checksum</u>
9	Total bytes in type x10,x20,x30 records

Data records - Power Out

The SAMI generates a record every time it powers an external device (e.g. a pump). The record structure is the same as above, except there is no voltage reading, so it is only 7 bytes. The type byte indicates the device in a convention similar to above with x11, x21, x31 indicating devices 1, 2 and 3.

Data records – Serial

The SAMI can read a serial device via any of the 3 device slots. Data records depend on whether the 'Serial Generic' driver or 'Serial Devices' driver is used when launching the SAMI. For the 'Serial Generic' driver you will get type x12 (18), x22 (34) or x32 (50) record type with following structure:

<i>Bytes</i>	<i>Description</i>
1	Length
1	Type
4	Time
n	ASCII character string of variable length
<u>1</u>	<u>Checksum</u>
n+7	Total bytes

For the serial devices driver, two additional bytes are added to help identify the instrument so the client can deal with it. Record types are x13 (19), x23 (35) or x33 (51) with following structure:

<i>Bytes</i>	<i>Description</i>
1	Length
1	Type
4	Time
1	sub-type instrument
1	flags
n	ASCII character string of variable length
1	<u>Checksum</u>
n+9	Total bytes

It is left to the client software to parse these characters into meaningful data, but knowing the following ASCII characters can allow for visual inspection and quick translation:

<i>ASCII</i>	<i>Hex code</i>
0-9	x30-39
,	x2C
.	x2E
space	x20
tab	x09
CR	x0D

Revisions

August 2020 - updated record descriptions and info on J boards

December 2020 - added missing control/error record descriptions and clarified packets vs records