Contents

1 Introduction and Scope

This document is designed to supply supplementary information for those OPC R1 users wishing to write their own programs to drive the OPC unit rather than relying on the supplied software.
This document should be used in conjunction with the OPC-R1 Optical Particle Counter Manual (072-0500).
A coding example, in the form of a flow chart, is provided, as well as additional information on timing, full details of all the SPI Commands and configuration information and also a list of OPC-R1 Factory settings.
The command list supplied is for firmware 2.1-2.21.

Sensor Technology House, 300 Avenue West, Skyline 120, Great Notley. Essex.CM77 7AA. UK
Tel: +44 (0) 1376 556700 - Fax: +44 (0) 1376 335899
Email: sensors@alphasense.com - Web: www.alphasense.com

2 Coding Example/flow chart

1. Set up SPI interface as follows:
   SPI Mode1 (clock idle low, data transmitted on clock leading edge).
   Set SPI frequency to between 300 kHz and 750 kHz.
2. SPI Master system must drive MOSI and SCK and SS communication lines.
3. Delay between a command byte and any subsequent bytes of an SPI communication should be > 10 ms (< 100 ms).
4. Delay between final byte of one SPI communication and first byte (command byte) of the next SPI communication should be > 10 ms (< 100 ms).
5. Interval between bytes following the command byte of an SPI communication should be > 10 µs (< 100 µs).
6. Under certain circumstances the intervals may need to be longer i.e. the interval between one 'Get Histogram' communication sequence and the next should be between 1 s and 20 s and no greater than 60 s. The interval after a 'Switch Peripherals/Fan on' sequence should be > 600 ms (< 2 s) to allow the firmware time to perform multiple attempts to switch the fan on.
   Normally users should allow a much longer time than this anyway e.g. 5-10 s to allow the fan to get up to speed. Following power-up, the OPC should be allowed at least 2 s to initialise before beginning SPI communication.
7. The first histogram data set in a session, or the first histogram obtained after any kind of error condition has passed, will have been recorded over an unknown sampling period and should be discarded.
8. The timings and SPI frequencies specified are guidelines only. Users may experiment with different timings at their own risk.
9. The SS connection to the OPC should be driven LOW during any SPI communication with the OPC.

Notes on Flow Chart:

The flow chart is an example of switching the OPC fan and peripheral power (laser) on and off and reading histogram data. Note the peripheral power (laser) and fan power may be controlled simultaneously with the OPC R1 firmware. If required, these can be controlled independently with appropriate SPI commands.

* 0x03 is SPI command byte to control fan and laser power state.
0x00 is SPI byte following 0x03 to turn peripherals (laser) and fan OFF (low power).
0x03 is SPI byte following 0x03 to turn peripherals (laser) and fan ON (normal power).
0x30 is SPI command byte to request a histogram data set.
0xF3 indicates OPC ready for SPI communication.
0x31 (not shown on flow chart) indicates OPC is busy and not yet ready for SPI communication.

A coding example for use with an Arduino Uno is available on request.

Sensor Technology House, 300 Avenue West, Skyline 120, Great Notley. Essex.CM77 7AA. UK
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Email: sensors@alphasense.com - Web: www.alphasense.com

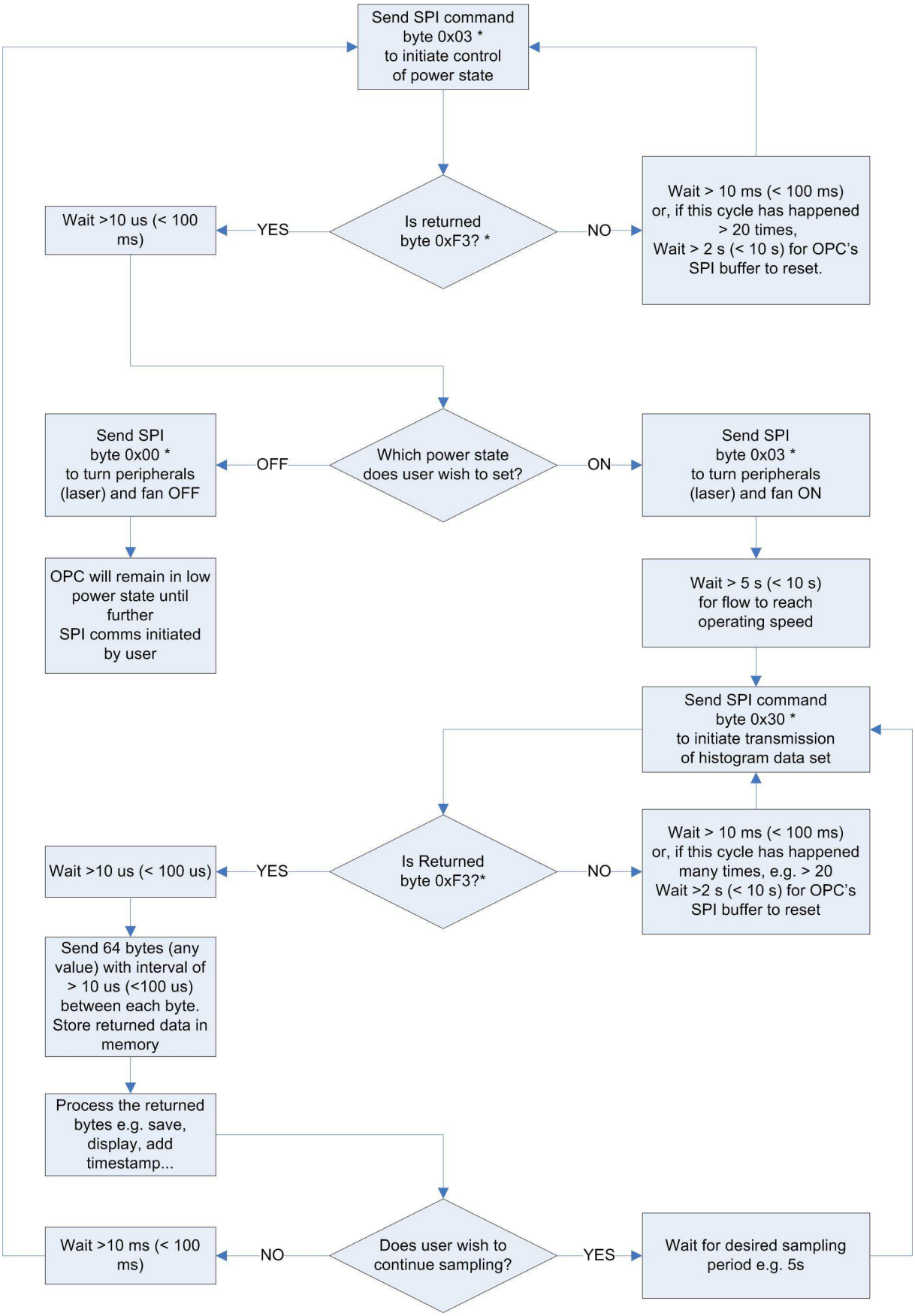

Figure 1: Flow chart depicting a typical sequence of commands and delays to run an OPC-R1 histogram sampling session.

Sensor Technology House, 300 Avenue West, Skyline 120, Great Notley. Essex.CM77 7AA. UK
Tel: +44 (0) 1376 556700 - Fax: +44 (0) 1376 335899
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3 General Guidelines

In response to any initial command byte, the OPC-R1 should return a byte of value 0x31, indicating it is busy.
Upon receiving a command byte OPC-R1 will stop its activities and prepare data for a response if required.
During this period, until the response data is ready, if further bytes are sent to the OPC-R1, the returned byte will continue to be 0x31 (busy). When the OPC-R1 has prepared its response data it will load the SPI buffer with a byte value 0xF3 to indicate it is ready to transfer data. The command byte value must remain consistent with the original command byte value sent for the command to be validated by the OPC-R1. If it is not, the OPC-R1 will load the SPI buffer with 0x31 (busy) value and return to its normal mode of operation. THE SAMPLING TRIGGER WILL NOT BE ARMED IF THIS OCCURS. Rearming of the trigger can be achieved by a successful histogram or PM data request.

To communicate with the OPC-R1, the SPI master should poll the OPC-R1 with the command byte value, checking the returned byte for the value 0x31 (busy) or 0xF3 (ready). The first returned byte should always be 0x31 (busy). Subsequent returned bytes will either be 0x31 (busy) or 0xF3 (ready) depending on the status of the OPC-R1. If another byte value is received by the SPI master at this stage, an error has occurred and communication should cease for > 2s to allow the OPC-R1 to realise the error and clear its buffered data. The SPI master should also clear any buffered data.

In general, it is suggested that the command byte polling interval is 10 ms and the delay between byte transfers following a receipt of byte value 0xF3 (ready) is 10 µs.

All PM data is a float variable occupying 4 bytes. This conforms to the IEEE-754 32bit floating point format. For floating point variables it is the byte labelled Byte3 in the SPI data spreadsheets that carries the sign bit and 7 of the exponent bits. Units are µg/m3.

4 Conversion of Signal Output from the temperature and humidity signal on the OPC-R1

Measurement data is always transferred as 16-bit values (unsigned integer). These values are already linearized and compensated for temperature and supply voltage effects. Converting those raw values into a physical scale can be achieved using the following formulas.
Relative humidity conversion formula (result in %RH):

$$RH = 100.\frac{S_{RH}}{2^{16}-1}$$

Temperature conversion formula (result in °C & °F):

$$T°C = -45 + 175.\frac{S_T}{2^{16}-1}$$

$$T°F = -49 + 347.\frac{S_T}{2^{16}-1}$$

S_{RH} and S_T denote the raw sensor output for humidity and temperature, respectively. The formulas only work correctly when S_{RH} and S_T are used in decimal representation.

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5 Comment on Checksum

A 16-bit CRC checksum is transmitted after each histogram data set, which can be used, if desired, to verify the data sent. If the OPC is configured to only transmit PM data, a checksum will still accompany this data.
The CRC calculation is a 16-bit method similar to that used in MODBUS communication. It uses the generator polynomial value 0xA001 and is initialised to 0xFFFF. Example 'C' programming code showing how the checksum can be recalculated is shown.

```
unsigned int CalcCRC(unsigned char data[], unsigned char nbrOfBytes)
{
  #define POLYNOMIAL 0xA001 //Generator polynomial for CRC
  #define InitCRCval 0xFFFF //Initial CRC value

  unsigned char _bit; // bit mask
  unsigned int crc = InitCRCval; // initialise calculated checksum
  unsigned char byteCtr; // byte counter

  // calculates 16-Bit checksum with given polynomial
  for(byteCtr = 0; byteCtr < nbrOfBytes; byteCtr++)
  {
    crc ^= (unsigned int)data[byteCtr];
    for(_bit = 0; _bit < 8; _bit++)
    {
      if (crc & 1) //if bit0 of crc is 1
      {
        crc >>= 1;
        crc ^= POLYNOMIAL;
      }
      else
        crc >>= 1;
    }
  }
  return crc;
}
```


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6 OPC-R1 Factory settings

The OPC firmware retains the factory settings and calibrations.
These settings should not be modified as this will affect the OPC calibration and its accuracy.
If you wish to modify any of these settings, then contact Alphasense at (+44) 1376 556700.

The following parameters are factory set and stored in the firmware:

Bin boundaries — The upper and lower particle size limits defining each of the 16 size bins. These are defined in ADC values and microns.

Bin weightings — Correction for size dependent sampling efficiency and density.
The OPC-R1 has 9 preset indexes of weightings and one end user configurable index (index 0). Note these are not all defined in initially released units. Index 2, which selects a particle density of 1.65 is recommended for most applications

Gain scaling coefficient — This is not utilised and is set at 1.0 on all units.

Laser digital pot setting — A parameter to determine laser beam power.

NOTE: Changing the laser power will change calibration and the OPC-R1 will require recalibration. When the OPC-R1 is not sampling, both the laser and fan are switched automatically to low-power settings/off.

7 Revision Control

Version	Comment	Release Date	Released by
A	First Draft	October 2017	Mark Giles
B	Second Draft	October 2017	Mark Giles
C	Third Draft	November 2017	Mark Giles
D	Fourth Draft (command corrections)	May 2018	Mark Giles
E	Fifth Draft (T and H additions)	August 2018	Mark Giles
F	FW 2.20	November 2018	Mark Giles
G	Re-ordering	January 2019	Mark Giles
1	Issue 1	February	Mark Giles

Sensor Technology House, 300 Avenue West, Skyline 120, Great Notley. Essex.CM77 7AA. UK
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Appendix Firmware Commands

OPC-R1 SPI functions (from point of view of SPI Master system) for firmware version 2.1-2.21.

Function	Command byte	Byte(s) out	Byte(s) in (0xF3 is set as standard initial return byte value from OPC-R1)	Notes
Peripheral/fan power ON/OFF	**0x03**	0x03	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x03	0xF3	
		Option byte	0x03	Bit 0 of this byte corresponds to peripheral (laser) power. Bit 1 corresponds to fan power. Bit value = 1 for ON, 0 for OFF.
Digital pot Set Laser Power	**0x04**	0x04	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x04	0xF3	
		LaserDAC	0x04	LaserDAC is an unsigned 8bit integer.
Set Bin Weighting Index	**0x05**	0x05	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x05	0xF3	
		BinWeightingIndex	0x05	BinWeightingIndex (0-10) is an unsigned 8bit integer that represents the index of the preset bin weightings to use.
Read information string	**0x3F**	0x3F	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x3F	0xF3	
		0x3F	InfoStr ascii char00: "O" (=0x4F)	SerialStr is a string of 60 characters. Note example is given, output dependant on FW loaded
		0x3F	InfoStr ascii char01: "P" (=0x50)	Value of shaded bytes doesn't matter.
		0x3F	InfoStr ascii char02: "C" (=0x43)	
		0x3F	InfoStr ascii char03: "-" (=0x2D)	
		0x3F	InfoStr ascii char04: "R" (=0x52)	
		0x3F	InfoStr ascii char05: "1" (=0x31)	
		0x3F	InfoStr ascii char06: " " (=0x20)	
		0x3F	InfoStr ascii char07: "F" (=0x46)	
		0x3F	InfoStr ascii char08: "i" (=0x69)	
		0x3F	InfoStr ascii char09: "r" (=0x72)	
		0x3F	InfoStr ascii char10: "m" (=0x6D)	
		0x3F	InfoStr ascii char11: "w" (=0x77)	

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		0x3F	InfoStr ascii char12: "a" (=0x61)	
		0x3F	InfoStr ascii char13: "r" (=0x72)	
		0x3F	InfoStr ascii char14: "e" (=0x65)	
		0x3F	InfoStr ascii char15: "V" (=0x56)	
		0x3F	InfoStr ascii char16: "e" (=0x65)	
		0x3F	InfoStr ascii char17: "r" (=0x72)	
		0x3F	InfoStr ascii char18: "=" (=0x3D)	
		0x3F	InfoStr ascii char19: "0" (=0x30)	
		0x3F	InfoStr ascii char20: "2" (=0x32)	
		0x3F	InfoStr ascii char21: "." (=0x2E)	
		0x3F	InfoStr ascii char22: "1" (=0x32)	
		0x3F	InfoStr ascii char23: "0" (=0x2E)	
		0x3F	InfoStr ascii char24: "." (=0x2E)	
		0x3F	InfoStr ascii char25: "." (=0x41)	
		0x3F	InfoStr ascii char26: "." (=0x2E)	
		0x3F	InfoStr ascii char27: "." (=0x2E)	
		0x3F	InfoStr ascii char28: "." (=0x2E)	
		0x3F	InfoStr ascii char29: "." (=0x2E)	
		0x3F	InfoStr ascii char30: "." (=0x2E)	
		0x3F	InfoStr ascii char31: "." (=0x2E)	
		0x3F	InfoStr ascii char32: "." (=0x2E)	
		0x3F	InfoStr ascii char33: "." (=0x2E)	
		0x3F	InfoStr ascii char34: "." (=0x2E)	
		0x3F	InfoStr ascii char35: "." (=0x2E)	
		0x3F	InfoStr ascii char36: "." (=0x2E)	
		0x3F	InfoStr ascii char37: "." (=0x2E)	
		0x3F	InfoStr ascii char38: "." (=0x2E)	
		0x3F	InfoStr ascii char39: "." (=0x2E)	
		0x3F	InfoStr ascii char40: "." (=0x2E)	
		0x3F	InfoStr ascii char41: "." (=0x2E)	
		0x3F	InfoStr ascii char42: "." (=0x2E)	
		0x3F	InfoStr ascii char43: "." (=0x2E)	
		0x3F	InfoStr ascii char44: "." (=0x2E)	
		0x3F	InfoStr ascii char45: "." (=0x2E)	
		0x3F	InfoStr ascii char46: "." (=0x2E)	
		0x3F	InfoStr ascii char47: "." (=0x2E)	
		0x3F	InfoStr ascii char48: "." (=0x2E)	
		0x3F	InfoStr ascii char49: "." (=0x2E)	
		0x3F	InfoStr ascii char50: "." (=0x2E)	
		0x3F	InfoStr ascii char51: "." (=0x2E)	
		0x3F	InfoStr ascii char52: "." (=0x2E)	
		0x3F	InfoStr ascii char53: "." (=0x2E)	
		0x3F	InfoStr ascii char54: "." (=0x2E)	
		0x3F	InfoStr ascii char55: "." (=0x2E)	
		0x3F	InfoStr ascii char56: "." (=0x2E)	
		0x3F	InfoStr ascii char57: "." (=0x2E)	
		0x3F	InfoStr ascii char58: "B" (=0x42)	
		0x3F	InfoStr ascii char59: "S" (=0x53)	

Sensor Technology House, 300 Avenue West, Skyline 120, Great Notley. Essex.CM77 7AA. UK
Tel: +44 (0) 1376 556700 - Fax: +44 (0) 1376 335899
Email: sensors@alphasense.com - Web: www.alphasense.com

Read serial number string	**0x10**	0x10	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x10	0xF3	
		0x10	SerialStr ascii char00	SerialStr is a string of 60 characters.
		0x10	SerialStr ascii char01	Value of shaded bytes doesn't matter.
		0x10	SerialStr ascii char02	
		0x10	SerialStr ascii char03	
		0x10	SerialStr ascii char04	
		0x10	SerialStr ascii char05	
		0x10	SerialStr ascii char06	
		0x10	SerialStr ascii char07	
		0x10	SerialStr ascii char08	
		0x10	SerialStr ascii char09	
		0x10	SerialStr ascii char10	
		0x10	SerialStr ascii char11	
		0x10	SerialStr ascii char12	
		0x10	SerialStr ascii char13	
		0x10	SerialStr ascii char14	
		0x10	SerialStr ascii char15	
		0x10	SerialStr ascii char16	
		0x10	SerialStr ascii char17	
		0x10	SerialStr ascii char18	
		0x10	SerialStr ascii char19	
		0x10	SerialStr ascii char20	
		0x10	SerialStr ascii char21	
		0x10	SerialStr ascii char22	
		0x10	SerialStr ascii char23	
		0x10	SerialStr ascii char24	
		0x10	SerialStr ascii char25	
		0x10	SerialStr ascii char26	
		0x10	SerialStr ascii char27	
		0x10	SerialStr ascii char28	
		0x10	SerialStr ascii char29	
		0x10	SerialStr ascii char30	
		0x10	SerialStr ascii char31	
		0x10	SerialStr ascii char32	
		0x10	SerialStr ascii char33	
		0x10	SerialStr ascii char34	
		0x10	SerialStr ascii char35	
		0x10	SerialStr ascii char36	
		0x10	SerialStr ascii char37	
		0x10	SerialStr ascii char38	
		0x10	SerialStr ascii char39	
		0x10	SerialStr ascii char40	
		0x10	SerialStr ascii char41	

Sensor Technology House, 300 Avenue West, Skyline 120, Great Notley. Essex.CM77 7AA. UK
Tel: +44 (0) 1376 556700 - Fax: +44 (0) 1376 335899
Email: sensors@alphasense.com - Web: www.alphasense.com

		0x10	SerialStr ascii char42	
		0x10	SerialStr ascii char43	
		0x10	SerialStr ascii char44	
		0x10	SerialStr ascii char45	
		0x10	SerialStr ascii char46	
		0x10	SerialStr ascii char47	
		0x10	SerialStr ascii char48	
		0x10	SerialStr ascii char49	
		0x10	SerialStr ascii char50	
		0x10	SerialStr ascii char51	
		0x10	SerialStr ascii char52	
		0x10	SerialStr ascii char53	
		0x10	SerialStr ascii char54	
		0x10	SerialStr ascii char55	
		0x10	SerialStr ascii char56	
		0x10	SerialStr ascii char57	
		0x10	SerialStr ascii char58	
		0x10	SerialStr ascii char59	
Write serial number string	**0x11**	0x11	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x11	0xF3	
		SerialStr ascii char00	0x11	SerialStr is a string of 60 characters. This string can only be written once.
		SerialStr ascii char01	SerialStr ascii char00	
		SerialStr ascii char02	SerialStr ascii char01	
		SerialStr ascii char03	SerialStr ascii char02	
		SerialStr ascii char04	SerialStr ascii char03	
		SerialStr ascii char05	SerialStr ascii char04	
		SerialStr ascii char06	SerialStr ascii char05	
		SerialStr ascii char07	SerialStr ascii char06	
		SerialStr ascii char08	SerialStr ascii char07	
		SerialStr ascii char09	SerialStr ascii char08	
		SerialStr ascii char10	SerialStr ascii char09	
		SerialStr ascii char11	SerialStr ascii char10	
		SerialStr ascii char12	SerialStr ascii char11	
		SerialStr ascii char13	SerialStr ascii char12	
		SerialStr ascii char14	SerialStr ascii char13	
		SerialStr ascii char15	SerialStr ascii char14	
		SerialStr ascii char16	SerialStr ascii char15	
		SerialStr ascii char17	SerialStr ascii char16	
		SerialStr ascii char18	SerialStr ascii char17	
		SerialStr ascii char19	SerialStr ascii char18	
		SerialStr ascii char20	SerialStr ascii char19	
		SerialStr ascii char21	SerialStr ascii char20	
		SerialStr ascii char22	SerialStr ascii char21	
		SerialStr ascii char23	SerialStr ascii char22	

Sensor Technology House, 300 Avenue West, Skyline 120, Great Notley. Essex.CM77 7AA. UK
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		SerialStr ascii char24	SerialStr ascii char23	
		SerialStr ascii char25	SerialStr ascii char24	
		SerialStr ascii char26	SerialStr ascii char25	
		SerialStr ascii char27	SerialStr ascii char26	
		SerialStr ascii char28	SerialStr ascii char27	
		SerialStr ascii char29	SerialStr ascii char28	
		SerialStr ascii char30	SerialStr ascii char29	
		SerialStr ascii char31	SerialStr ascii char30	
		SerialStr ascii char32	SerialStr ascii char31	
		SerialStr ascii char33	SerialStr ascii char32	
		SerialStr ascii char34	SerialStr ascii char33	
		SerialStr ascii char35	SerialStr ascii char34	
		SerialStr ascii char36	SerialStr ascii char35	
		SerialStr ascii char37	SerialStr ascii char36	
		SerialStr ascii char38	SerialStr ascii char37	
		SerialStr ascii char39	SerialStr ascii char38	
		SerialStr ascii char40	SerialStr ascii char39	
		SerialStr ascii char41	SerialStr ascii char40	
		SerialStr ascii char42	SerialStr ascii char41	
		SerialStr ascii char43	SerialStr ascii char42	
		SerialStr ascii char44	SerialStr ascii char43	
		SerialStr ascii char45	SerialStr ascii char44	
		SerialStr ascii char46	SerialStr ascii char45	
		SerialStr ascii char47	SerialStr ascii char46	
		SerialStr ascii char48	SerialStr ascii char47	
		SerialStr ascii char49	SerialStr ascii char48	
		SerialStr ascii char50	SerialStr ascii char49	
		SerialStr ascii char51	SerialStr ascii char50	
		SerialStr ascii char52	SerialStr ascii char51	
		SerialStr ascii char53	SerialStr ascii char52	
		SerialStr ascii char54	SerialStr ascii char53	
		SerialStr ascii char55	SerialStr ascii char54	
		SerialStr ascii char56	SerialStr ascii char55	
		SerialStr ascii char57	SerialStr ascii char56	
		SerialStr ascii char58	SerialStr ascii char57	
		SerialStr ascii char59	SerialStr ascii char58	
Read Firmware Version	0x12	0x12	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x12	0xF3	
		0x12	FirmwareVerMajor	FirmwareVerMajor is unsigned 8bit integer variable.
		0x12	FirmwareVerMinor	FirmwareVerMinor is unsigned 8bit integer variable.
Read Configuration Variables	**0x3C**	0x3C	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x3C	0xF3	

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		0x3C	BB0 LSB	Bin Boundaries ADC (BB0 – BB16) are unsigned 16bit integer variables.
		0x3C	BB0 MSB	
		0x3C	BB1 LSB	
		0x3C	BB1 MSB	
		0x3C	BB2 LSB	
		0x3C	BB2 MSB	
		0x3C	BB3 LSB	
		0x3C	BB3 MSB	
		0x3C	BB4 LSB	
		0x3C	BB4 MSB	
		0x3C	BB5 LSB	
		0x3C	BB5 MSB	
		0x3C	BB6 LSB	
		0x3C	BB6 MSB	
		0x3C	BB7 LSB	
		0x3C	BB7 MSB	
		0x3C	BB8 LSB	
		0x3C	BB8 MSB	
		0x3C	BB9 LSB	
		0x3C	BB9 MSB	
		0x3C	BB10 LSB	
		0x3C	BB10 MSB	
		0x3C	BB11 LSB	
		0x3C	BB11 MSB	
		0x3C	BB12 LSB	
		0x3C	BB12 MSB	
		0x3C	BB13 LSB	
		0x3C	BB13 MSB	
		0x3C	BB14 LSB	
		0x3C	BB14 MSB	
		0x3C	BB15 LSB	
		0x3C	BB15 MSB	
		0x3C	BB16 LSB	
		0x3C	BB16 MSB	
		0x3C	BBD0 Byte0	Bin Boundaries diameter (um) (BBD0 – BBD16) are float variables occupying 4 bytes each.
		0x3C	BBD0 Byte1	
		0x3C	BBD0 Byte2	
		0x3C	BBD0 Byte3	
		0x3C	BBD1 Byte0	
		0x3C	BBD1 Byte1	
		0x3C	BBD1 Byte2	
		0x3C	BBD1 Byte3	
		0x3C	BBD2 Byte0	

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0x3C	BBD2 Byte1
0x3C	BBD2 Byte2
0x3C	BBD2 Byte3
0x3C	BBD3 Byte0
0x3C	BBD3 Byte1
0x3C	BBD3 Byte2
0x3C	BBD3 Byte3
0x3C	BBD4 Byte0
0x3C	BBD4 Byte1
0x3C	BBD4 Byte2
0x3C	BBD4 Byte3
0x3C	BBD5 Byte0
0x3C	BBD5 Byte1
0x3C	BBD5 Byte2
0x3C	BBD5 Byte3
0x3C	BBD6 Byte0
0x3C	BBD6 Byte1
0x3C	BBD6 Byte2
0x3C	BBD6 Byte3
0x3C	BBD7 Byte0
0x3C	BBD7 Byte1
0x3C	BBD7 Byte2
0x3C	BBD7 Byte3
0x3C	BBD Byte0
0x3C	BBD8 Byte1
0x3C	BBD8 Byte2
0x3C	BBD8 Byte3
0x3C	BBD9 Byte0
0x3C	BBD9 Byte1
0x3C	BBD9 Byte2
0x3C	BBD9 Byte3
0x3C	BBD10 Byte0
0x3C	BBD10 Byte1
0x3C	BBD10 Byte2
0x3C	BBD10 Byte3
0x3C	BBD11 Byte0
0x3C	BBD11 Byte1
0x3C	BBD11 Byte2
0x3C	BBD11 Byte3
0x3C	BBD12 Byte0
0x3C	BBD12 Byte1
0x3C	BBD12 Byte2
0x3C	BBD12 Byte3
0x3C	BBD13 Byte0
0x3C	BBD13 Byte1
0x3C	BBD13 Byte2
0x3C	BBD13 Byte3
0x3C	BBD14 Byte0

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		0x3C	BBD14 Byte1	
		0x3C	BBD14 Byte2	
		0x3C	BBD14 Byte3	
		0x3C	BBD15 Byte0	
		0x3C	BBD15 Byte1	
		0x3C	BBD15 Byte2	
		0x3C	BBD15 Byte3	
		0x3C	BBD16 Byte0	
		0x3C	BBD16 Byte1	
		0x3C	BBD16 Byte2	
		0x3C	BBD16 Byte3	
		0x3C	BW0 Byte0	Bin Weightings (BW0 – BW15) are float variables occupying 4 bytes each.
		0x3C	BW0 Byte1	
		0x3C	BW0 Byte2	
		0x3C	BW0 Byte3	
		0x3C	BW1 Byte0	
		0x3C	BW1 Byte1	
		0x3C	BW1 Byte2	
		0x3C	BW1 Byte3	
		0x3C	BW2 Byte0	
		0x3C	BW2 Byte1	
		0x3C	BW2 Byte2	
		0x3C	BW2 Byte3	
		0x3C	BW3 Byte0	
		0x3C	BW3 Byte1	
		0x3C	BW3 Byte2	
		0x3C	BW3 Byte3	
		0x3C	BW4 Byte0	
		0x3C	BW4 Byte1	
		0x3C	BW4 Byte2	
		0x3C	BW4 Byte3	
		0x3C	BW5 Byte0	
		0x3C	BW5 Byte1	
		0x3C	BW5 Byte2	
		0x3C	BW5 Byte3	
		0x3C	BW6 Byte0	
		0x3C	BW6 Byte1	
		0x3C	BW6 Byte2	
		0x3C	BW6 Byte3	
		0x3C	BW7 Byte0	
		0x3C	BW7 Byte1	
		0x3C	BW7 Byte2	
		0x3C	BW7 Byte3	
		0x3C	BW8 Byte0	
		0x3C	BW8 Byte1	
		0x3C	BW8 Byte2	

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		0x3C	BW8 Byte3	
		0x3C	BW9 Byte0	
		0x3C	BW9 Byte1	
		0x3C	BW9 Byte2	
		0x3C	BW9 Byte3	
		0x3C	BW10 Byte0	
		0x3C	BW10 Byte1	
		0x3C	BW10 Byte2	
		0x3C	BW10 Byte3	
		0x3C	BW11 Byte0	
		0x3C	BW11 Byte1	
		0x3C	BW11 Byte2	
		0x3C	BW11 Byte3	
		0x3C	BW12 Byte0	
		0x3C	BW12 Byte1	
		0x3C	BW12 Byte2	
		0x3C	BW12 Byte3	
		0x3C	BW13 Byte0	
		0x3C	BW13 Byte1	
		0x3C	BW13 Byte2	
		0x3C	BW13 Byte3	
		0x3C	BW14 Byte0	
		0x3C	BW14 Byte1	
		0x3C	BW14 Byte2	
		0x3C	BW14 Byte3	
		0x3C	BW15 Byte0	
		0x3C	BW15 Byte1	
		0x3C	BW15 Byte2	
		0x3C	BW15 Byte3	
		0x3C	GSC Byte0	Gain Scaling Coefficient (GSC) is float variable occupying 4 bytes.
		0x3C	GSC Byte1	
		0x3C	GSC Byte2	
		0x3C	GSC Byte3	
		0x3C	SFR Byte0	Sample Flow Rate' is a float variable occupying 4 bytes that represents the sample flow rate in ml/s.
		0x3C	SFR Byte1	
		0x3C	SFR Byte2	
		0x3C	SFR Byte3	
		0x3C	TOF to SFR factor	Time of Flight to Sample Flow Rate conversion factor' is unsigned 8bit integer variable.
		0x3C	M_A Byte0	M_A (Particle mass Concentration A) is float variable occupying 4 bytes.
		0x3C	M_A Byte1	

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		0x3C	M_A Byte2	
		0x3C	M_A Byte3	
		0x3C	M_B Byte0	M_B (Particle mass Concentration B) is float variable occupying 4 bytes.
		0x3C	M_B Byte1	
		0x3C	M_B Byte2	
		0x3C	M_B Byte3	
		0x3C	M_C Byte0	M_C (Particle mass Concentration C) is float variable occupying 4 bytes.
		0x3C	M_C Byte1	
		0x3C	M_C Byte2	
		0x3C	M_C Byte3	
		0x3C	PVP	PVP (Particle Validation Period) is unsigned 8bit integer variable.
		0x3C	PowerStatus	Power Status is unsigned 8bit integer variable. Bit 0 controls laser and peripheral power. Bit 1 controls fan power.
		0x3C	MaxTOF Byte0	MaxTOF (Maximum Time Of Flight) is unsigned 16bit integer variable.
		0x3C	MaxTOF Byte1	
		0x3C	LaserDAC	LaserDAC is unsigned 8bit integer variable.
		0x3C	BinWeightingIndex	BinWeightingIndex (0-10) is an unsigned 8bit integer that represents the index of the preset bin weightings to use.
Write Configuration Variables	**0x3A**	0x3A	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x3A	0xF3	
		BB0 LSB	0x3A	Bin Boundaries ADC (BB0 – BB16) are unsigned 16bit integer variables.
		BB0 MSB	BB0 LSB	Value of shaded bytes doesn't matter.
		BB1 LSB	BB0 MSB	
		BB1 MSB	BB1 LSB	
		BB2 LSB	BB1 MSB	
		BB2 MSB	BB2 LSB	
		BB3 LSB	BB2 MSB	
		BB3 MSB	BB3 LSB	
		BB4 LSB	BB3 MSB	
		BB4 MSB	BB4 LSB	

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		BB5 LSB	BB4 MSB	
		BB5 MSB	BB5 LSB	
		BB6 LSB	BB5 MSB	
		BB6 MSB	BB6 LSB	
		BB7 LSB	BB6 MSB	
		BB7 MSB	BB7 LSB	
		BB8 LSB	BB7 MSB	
		BB8 MSB	BB8 LSB	
		BB9 LSB	BB8 MSB	
		BB9 MSB	BB9 LSB	
		BB10 LSB	BB9 MSB	
		BB10 MSB	BB10 LSB	
		BB11 LSB	BB10 MSB	
		BB11 MSB	BB11 LSB	
		BB12 LSB	BB11 MSB	
		BB12 MSB	BB12 LSB	
		BB13 LSB	BB12 MSB	
		BB13 MSB	BB13 LSB	
		BB14 LSB	BB13 MSB	
		BB14 MSB	BB14 LSB	
		BB15 LSB	BB14 MSB	
		BB15 MSB	BB15 LSB	
		BB16 LSB	BB15 MSB	
		BB16 MSB	BB16 LSB	
		BBD0 Byte0	BB16 MSB	Bin Boundaries diameter (um) (BBD0 – BBD16) are float variables occupying 4 bytes each.
		BBD0 Byte1	BBD0 Byte0	
		BBD0 Byte2	BBD0 Byte1	
		BBD0 Byte3	BBD0 Byte2	
		BBD1 Byte0	BBD0 Byte3	
		BBD1 Byte1	BBD1 Byte0	
		BBD1 Byte2	BBD1 Byte1	
		BBD1 Byte3	BBD1 Byte2	
		BBD2 Byte0	BBD1 Byte3	
		BBD2 Byte1	BBD2 Byte0	
		BBD2 Byte2	BBD2 Byte1	
		BBD2 Byte3	BBD2 Byte2	
		BBD3 Byte0	BBD2 Byte3	
		BBD3 Byte1	BBD3 Byte0	
		BBD3 Byte2	BBD3 Byte1	
		BBD3 Byte3	BBD3 Byte2	
		BBD4 Byte0	BBD3 Byte3	
		BBD4 Byte1	BBD4 Byte0	
		BBD4 Byte2	BBD4 Byte1	
		BBD4 Byte3	BBD4 Byte2	
		BBD5 Byte0	BBD4 Byte3	
		BBD5 Byte1	BBD5 Byte0	

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BBD5 Byte2	BBD5 Byte1
BBD5 Byte3	BBD5 Byte2
BBD6 Byte0	BBD5 Byte3
BBD6 Byte1	BBD6 Byte0
BBD6 Byte2	BBD6 Byte1
BBD6 Byte3	BBD6 Byte2
BBD7 Byte0	BBD6 Byte3
BBD7 Byte1	BBD7 Byte0
BBD7 Byte2	BBD7 Byte1
BBD7 Byte3	BBD7 Byte2
BBD8 Byte0	BBD7 Byte3
BBD8 Byte1	BBD8 Byte0
BBD8 Byte2	BBD8 Byte1
BBD8 Byte3	BBD8 Byte2
BBD9 Byte0	BBD8 Byte3
BBD9 Byte1	BBD9 Byte0
BBD9 Byte2	BBD9 Byte1
BBD9 Byte3	BBD9 Byte2
BBD10 Byte0	BBD9 Byte3
BBD10 Byte1	BBD10 Byte0
BBD10 Byte2	BBD10 Byte1
BBD10 Byte3	BBD10 Byte2
BBD11 Byte0	BBD10 Byte3
BBD11 Byte1	BBD11 Byte0
BBD11 Byte2	BBD11 Byte1
BBD11 Byte3	BBD11 Byte2
BBD12 Byte0	BBD11 Byte3
BBD12 Byte1	BBD12 Byte0
BBD12 Byte2	BBD12 Byte1
BBD12 Byte3	BBD12 Byte2
BBD13 Byte0	BBD12 Byte3
BBD13 Byte1	BBD13 Byte0
BBD13 Byte2	BBD13 Byte1
BBD13 Byte3	BBD13 Byte2
BBD14 Byte0	BBD13 Byte3
BBD14 Byte1	BBD14 Byte0
BBD14 Byte2	BBD14 Byte1
BBD14 Byte3	BBD14 Byte2
BBD15 Byte0	BBD14 Byte3
BBD15 Byte1	BBD15 Byte0
BBD15 Byte2	BBD15 Byte1
BBD15 Byte3	BBD15 Byte2
BBD16 Byte0	BBD15 Byte3
BBD16 Byte1	BBD16 Byte0
BBD16 Byte2	BBD16 Byte1
BBD16 Byte3	BBD16 Byte2

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		BW0 Byte0	BBD16 Byte3	Bin Weightings (BW0 – BW15) are float variables occupying 4 bytes each.
		BW0 Byte1	BW0 Byte0	
		BW0 Byte2	BW0 Byte1	
		BW0 Byte3	BW0 Byte2	
		BW1 Byte0	BW0 Byte3	
		BW1 Byte1	BW1 Byte0	
		BW1 Byte2	BW1 Byte1	
		BW1 Byte3	BW1 Byte2	
		BW2 Byte0	BW1 Byte3	
		BW2 Byte1	BW2 Byte0	
		BW2 Byte2	BW2 Byte1	
		BW2 Byte3	BW2 Byte2	
		BW3 Byte0	BW2 Byte3	
		BW3 Byte1	BW3 Byte0	
		BW3 Byte2	BW3 Byte1	
		BW3 Byte3	BW3 Byte2	
		BW4 Byte0	BW3 Byte3	
		BW4 Byte1	BW4 Byte0	
		BW4 Byte2	BW4 Byte1	
		BW4 Byte3	BW4 Byte2	
		BW5 Byte0	BW4 Byte3	
		BW5 Byte1	BW5 Byte0	
		BW5 Byte2	BW5 Byte1	
		BW5 Byte3	BW5 Byte2	
		BW6 Byte0	BW5 Byte3	
		BW6 Byte1	BW6 Byte0	
		BW6 Byte2	BW6 Byte1	
		BW6 Byte3	BW6 Byte2	
		BW7 Byte0	BW6 Byte3	
		BW7 Byte1	BW7 Byte0	
		BW7 Byte2	BW7 Byte1	
		BW7 Byte3	BW7 Byte2	
		BW8 Byte0	BW7 Byte3	
		BW8 Byte1	BW8 Byte0	
		BW8 Byte2	BW8 Byte1	
		BW8 Byte3	BW8 Byte2	
		BW9 Byte0	BW8 Byte3	
		BW9 Byte1	BW9 Byte0	
		BW9 Byte2	BW9 Byte1	
		BW9 Byte3	BW9 Byte2	
		BW10 Byte0	BW9 Byte3	
		BW10 Byte1	BW10 Byte0	
		BW10 Byte2	BW10 Byte1	
		BW10 Byte3	BW10 Byte2	
		BW11 Byte0	BW10 Byte3	
		BW11 Byte1	BW11 Byte0	

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BW11 Byte2	BW11 Byte1	
BW11 Byte3	BW11 Byte2	
BW12 Byte0	BW11 Byte3	
BW12 Byte1	BW12 Byte0	
BW12 Byte2	BW12 Byte1	
BW12 Byte3	BW12 Byte2	
BW13 Byte0	BW12 Byte3	
BW13 Byte1	BW13 Byte0	
BW13 Byte2	BW13 Byte1	
BW13 Byte3	BW13 Byte2	
BW14 Byte0	BW13 Byte3	
BW14 Byte1	BW14 Byte0	
BW14 Byte2	BW14 Byte1	
BW14 Byte3	BW14 Byte2	
BW15 Byte0	BW14 Byte3	
BW15 Byte1	BW15 Byte0	
BW15 Byte2	BW15 Byte1	
BW15 Byte3	BW15 Byte2	
GSC Byte0	BW15 Byte3	Gain Scaling Coefficient (GSC) is float variable occupying 4 bytes.
GSC Byte1	GSC Byte0	
GSC Byte2	GSC Byte1	
GSC Byte3	GSC Byte2	
M_A Byte0	GSC Byte3	M_A (Particle mass Concentration A) is float variable occupying 4 bytes.
M_A Byte1	M_A Byte0	
M_A Byte2	M_A Byte1	
M_A Byte3	M_A Byte2	
M_B Byte0	M_A Byte3	M_B (Particle mass Concentration B) is float variable occupying 4 bytes.
M_B Byte1	M_B Byte0	
M_B Byte2	M_B Byte1	
M_B Byte3	M_B Byte2	
M_C Byte0	M_B Byte3	M_C (Particle mass Concentration C) is float variable occupying 4 bytes.
M_C Byte1	M_C Byte0	
M_C Byte2	M_C Byte1	
M_C Byte3	M_C Byte2	
TOF to SFR factor	M_C Byte3	Time of Flight to Sample Flow Rate conversion factor' is unsigned 8bit integer variable.
PVP	TOF to SFR factor	PVP (Particle Validation Period) is unsigned 8bit integer variable.

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		MaxTOF Byte0	PVP	MaxTOF (Maximum Time Of Flight) is unsigned 16bit integer variable.
		MaxTOF Byte1	MaxTOF Byte0	
Read histogram data (and reset histogram)	**0x30**	0x30	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x30	0xF3	
		0x30	Bin0 LSB	Bin Counts (Bin0 - Bin15) are unsigned 16bit integer variables.
		0x30	Bin0 MSB	Value of shaded bytes doesn't matter.
		0x30	Bin1 LSB	
		0x30	Bin1 MSB	
		0x30	Bin2 LSB	
		0x30	Bin2 MSB	
		0x30	Bin3 LSB	
		0x30	Bin3 MSB	
		0x30	Bin4 LSB	
		0x30	Bin4 MSB	
		0x30	Bin5 LSB	
		0x30	Bin5 MSB	
		0x30	Bin6 LSB	
		0x30	Bin6 MSB	
		0x30	Bin7 LSB	
		0x30	Bin7 MSB	
		0x30	Bin8 LSB	
		0x30	Bin8 MSB	
		0x30	Bin9 LSB	
		0x30	Bin9 MSB	
		0x30	Bin10 LSB	
		0x30	Bin10 MSB	
		0x30	Bin11 LSB	
		0x30	Bin11 MSB	
		0x30	Bin12 LSB	
		0x30	Bin12 MSB	
		0x30	Bin13 LSB	
		0x30	Bin13 MSB	
		0x30	Bin14 LSB	
		0x30	Bin14 MSB	
		0x30	Bin15 LSB	
		0x30	Bin15 MSB	
		0x30	Bin1 MToF	'MToF' is an unsigned 8bit integer that represents the average
		0x30	Bin3 MToF	amount of time that particles sized in the stated bin took to
		0x30	Bin5 MToF	cross the OPS's laser beam. Each value is in 1/3 us. i.e. a value

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		0x30	Bin7 MToF	of 10 would represent 3.33us.
		0x30	Sample Flow Rate Byte0	'Sample Flow Rate' is a float variable occupying 4 bytes that represents the sample flow rate in ml/s.
		0x30	Sample Flow Rate Byte1	
		0x30	Sample Flow Rate Byte2	
		0x30	Sample Flow Rate Byte3	
		0x30	Temperature Byte0	Temperature is unsigned 16bit integer.
		0x30	Temperature Byte1	
		0x30	Relative humidity Byte0	Relative humidity is unsigned 16bit integer.
		0x30	Relative humidity Byte1	
		0x30	Sampling Period Byte0	Sampling Period' is a float variable occupying 4 bytes and is a
		0x30	Sampling Period Byte1	measure of the histogram's actual sampling period in seconds.
		0x30	Sampling Period Byte2	
		0x30	Sampling Period Byte3	
		0x30	Reject count Glitch	'Reject count Glitch' is unsigned 8bit integer.
		0x30	Reject count Long	'Reject count Long' is unsigned 8bit integer.
		0x30	PM_A Byte0	PM_A is a float variable occupying 4 bytes. Units are ug/m3.
		0x30	PM_A Byte1	
		0x30	PM_A Byte2	
		0x30	PM_A Byte3	
		0x30	PM_B Byte0	PM_B is a float variable occupying 4 bytes. Units are ug/m3.
		0x30	PM_B Byte1	
		0x30	PM_B Byte2	
		0x30	PM_B Byte3	
		0x30	PM_C Byte0	PM_C is a float variable occupying 4 bytes. Units are ug/m3.
		0x30	PM_C Byte1	
		0x30	PM_C Byte2	
		0x30	PM_C Byte3	
		0x30	Checksum Byte0	Checksum is unsigned 16bit integer.
		0x30	Checksum Byte1	
Read PM data (and reset histogram)	**0x32**	0x32	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x32	0xF3	

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		0x32	PM_A Byte0	PM_A is a float variable occupying 4 bytes. Units are ug/m3.
		0x32	PM_A Byte1	
		0x32	PM_A Byte2	
		0x32	PM_A Byte3	
		0x32	PM_B Byte0	PM_B is a float variable occupying 4 bytes. Units are ug/m3.
		0x32	PM_B Byte1	
		0x32	PM_B Byte2	
		0x32	PM_B Byte3	
		0x32	PM_C Byte0	PM_C is a float variable occupying 4 bytes. Units are ug/m3.
		0x32	PM_C Byte1	
		0x32	PM_C Byte2	
		0x32	PM_C Byte3	
		0x32	Checksum Byte0	Checksum is unsigned 16bit integer.
		0x32	Checksum Byte1	
Save Configuration Variables in non-volatile memory	**0x43**	0x43	0x31	Suggest that 10 ms be used as delay between command byte and following byte.
		0x43	0xF3	
		0x3F	0x43	Initial command byte must be followed by sequence of bytes (shown in red).
		0x3C	0x3F	
		0x3F	0x3C	
		0x3C	0x3F	
		0x43	0x3C	
Check Status	**0xCF**	0xCF	0x31	
		0xCF	0xF3	
Reset	**0x06**	0x06	0x31	
		0x06	0xF3	
Enter bootloader mode	**0x41**	0x41	0x31	
		0x41	0xF3	

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