Contents

1 Introduction and Scope

This document is designed to supply supplementary information for those OPC-N3 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-N3 Optical Particle Counter Manual (072-0502).
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-N3 Factory settings.
The command list supplied is for firmware 1.14 - 1.17.

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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 0.5 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 OPC-N3 Flow Chart:

The flow chart is an example of switching the OPC fan on and off and reading histogram data. For clarity laser power is not controlled in this example and may be off when histogram data is read. The user can add laser power control to their code in a similar way to the fan power control in the example.

* 0x03 is SPI command byte to control power states of OPC peripherals: fan, laser etc.
0x02 is SPI byte following 0x03 to turn fan OFF.
0x03 is SPI byte following 0x03 to turn fan ON.
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.

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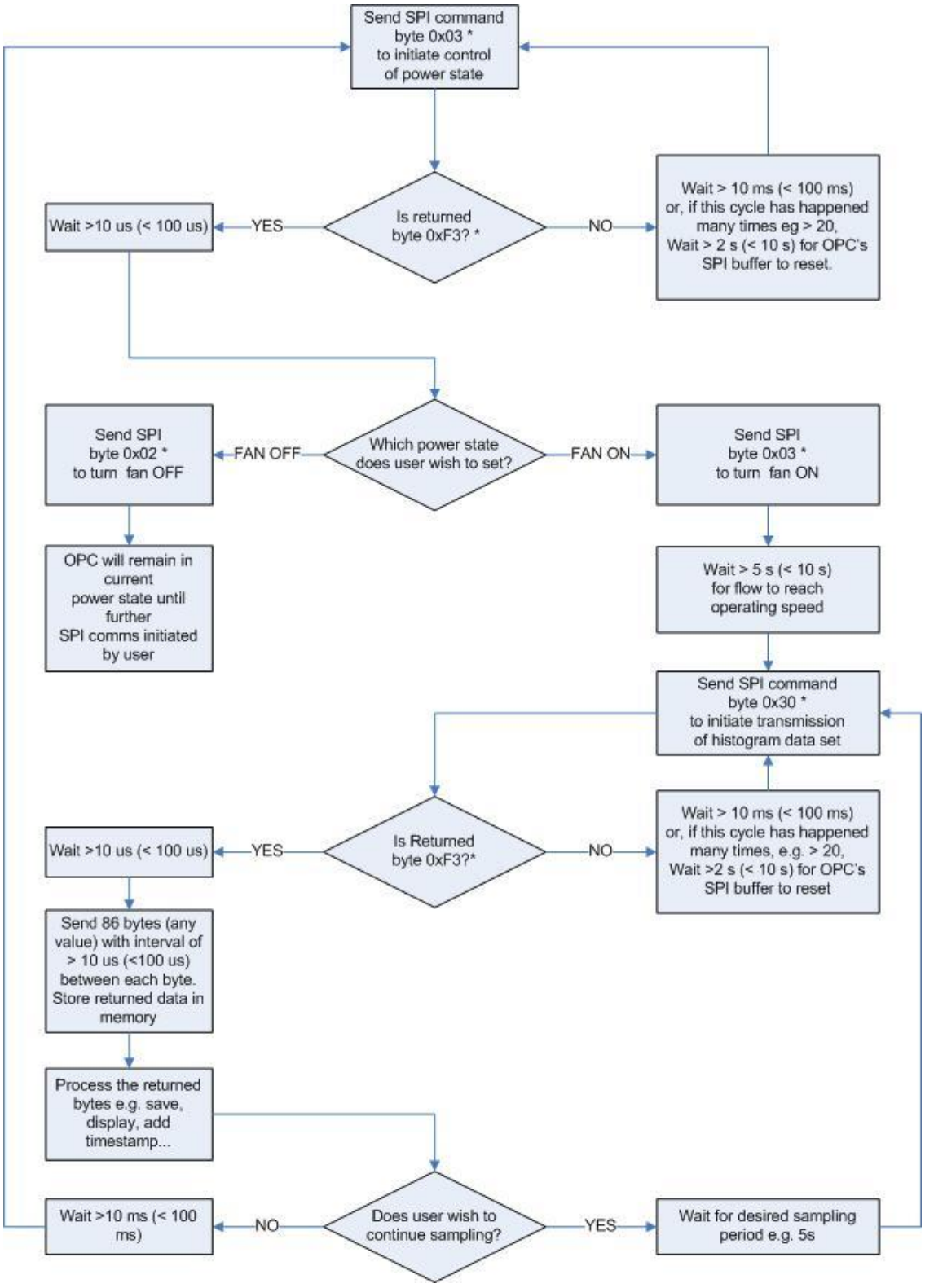

Figure 1: Flow chart depicting a typical sequence of commands and delays to run an OPC-N3 histogram sampling session. (Note control of the laser is left off for clarity)

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3 Firmware commands

OPC-N3 SPI functions (from point of view of SPI Master system) for firmware version 1.14-1.17.

Function	Command byte	Byte(s) out	Byte(s) in (0xF3 is set as standard initial return byte value from OPC-N3)	Notes
Write peripheral power status	**0x03**	0x03	0x31	Suggest that 10ms be used as delay between command byte and following byte.
		0x03	0xF3	
		OptionByte	0x03	OptionByte is an 8bit unsigned integer variable. Bit 0 indicates the required power status. The remaining bits select the target peripheral as follows: Before the status bit 0 is applied, if the Option byte is set to the value 1 and then shifted left one bit this will select the 'Fan digital pot shutdown state' as the target. Similarly, if the Option byte is first set to the value 2, this will select 'Laser digital pot shutdown state' as the target. Setting the option byte to 3 will select 'Laser power switch state' and setting to 4 will select 'High/Low gain state'. Only one peripheral can be set at a time.
Read DAC and power status	**0x13**	0x13	0x31	Suggest that 10ms be used as delay between command byte and following byte.
		0x13	0xF3	
		0x13	Fan_ON	Fan_ON is an 8bit unsigned integer variable.
		0x13	LaserDAC_ON	LaserDAC_ON is an 8bit unsigned integer variable.
		0x13	FanDACval	FanDACval is an 8bit unsigned integer variable.
		0x13	LaserDACval	LaserDACval is an 8bit unsigned integer variable.
		0x13	LaserSwitch	LaserSwitch is an 8bit unsigned integer variable.
		0x13	Gain and AutoGainToggle setting	AutoGainToggle comprises Gain and AutoGainToggle settings. Unsigned 8bit integer.
Set Fan or Laser digital pot	**0x42**	0x42	0x31	Suggest that 10ms be used as delay between command byte and following byte.
		0x42	0xF3	
		Channel Digital pot setting	0x42 Channel	Channel is 0 for Fan, 1 for Laser. Digital pot setting is unsigned 8bit integer variable.
Set Bin Weighting Index	**0x05**	0x05	0x31	Suggest that 10ms be used as delay between command byte and following byte.
		0x05	0xF3	

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		BinWeightingIndex	0x05	BinWeightingIndex (0-10) is an 8bit unsigned integer that represents the index of the preset bin weightings to use.
Read information string	**0x3F**	0x3F	0x31	Suggest that 10ms 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.
		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: "N" (=0x4E)	
		0x3F	InfoStr ascii char05: "3" (=0x33)	
		0x3F	InfoStr ascii char06: " " (=0x20)	
		0x3F	InfoStr ascii char07: "I" (=0x49)	
		0x3F	InfoStr ascii char08: "s" (=0x73)	
		0x3F	InfoStr ascii char09: "s" (=0x73)	
		0x3F	InfoStr ascii char10: "1" (=0x31)	
		0x3F	InfoStr ascii char11: "." (=0x2E)	
		0x3F	InfoStr ascii char12: "1" (=0x31)	
		0x3F	InfoStr ascii char13: " " (=0x20)	
		0x3F	InfoStr ascii char14: "F" (=0x46)	
		0x3F	InfoStr ascii char15: "i" (=0x69)	
		0x3F	InfoStr ascii char16: "r" (=0x72)	
		0x3F	InfoStr ascii char17: "m" (=0x6D)	
		0x3F	InfoStr ascii char18: "w" (=0x77)	
		0x3F	InfoStr ascii char19: "a" (=0x61)	
		0x3F	InfoStr ascii char20: "r" (=0x72)	
		0x3F	InfoStr ascii char21: "e" (=0x65)	
		0x3F	InfoStr ascii char22: "V" (=0x56)	
		0x3F	InfoStr ascii char23: "e" (=0x65)	
		0x3F	InfoStr ascii char24: "r" (=0x72)	
		0x3F	InfoStr ascii char25: "=" (=0x3D)	
		0x3F	InfoStr ascii char26: "1" (=0x31)	
		0x3F	InfoStr ascii char27: "." (=0x2E)	
		0x3F	InfoStr ascii char28: "1" (=0x31)	
		0x3F	InfoStr ascii char29: "6" (=0x34)	
		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)	

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		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)	
Read serial number string	**0x10**	0x10	0x31	Suggest that 10ms 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	

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		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	
		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 10ms 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	

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		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	
		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 10ms be used as delay between command byte and following byte.
		0x12	0xF3	
		0x12	FirmwareVerMajor	FirmwareVerMajor is an 8bit unsigned integer variable.
		0x12	FirmwareVerMinor	FirmwareVerMinor is an 8bit unsigned integer variable.

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Read Configuration Variables	**0x3C**	0x3C	0x31	Suggest that 10ms be used as delay between command byte and following byte.
		0x3C	0xF3	
		0x3C	BB0 LSB	Bin Boundaries ADC (BB0 – BB24) are 16bit unsigned integer variables.
		0x3C	BB0 MSB	Value of shaded bytes doesn't matter.
		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	BB17 LSB	
		0x3C	BB17 MSB	
		0x3C	BB18 LSB	
		0x3C	BB18 MSB	
		0x3C	BB19 LSB	
		0x3C	BB19 MSB	
		0x3C	BB20 LSB	
		0x3C	BB20 MSB	
		0x3C	BB21 LSB	
		0x3C	BB21 MSB	
		0x3C	BB22 LSB	
		0x3C	BB22 MSB	
		0x3C	BB23 LSB	
		0x3C	BB23 MSB	
		0x3C	BB24 LSB	
		0x3C	BB24 MSB	
		0x3C	BBD0 LSB	Bin Boundaries diameter(um) (BBD0 – BBD24) are 16bit unsigned integer variables representing the diameter in um x100.
		0x3C	BBD0 MSB	
		0x3C	BBD1 LSB	

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		0x3C	BBD1 MSB	
		0x3C	BBD2 LSB	
		0x3C	BBD2 MSB	
		0x3C	BBD3 LSB	
		0x3C	BBD3 MSB	
		0x3C	BBD4 LSB	
		0x3C	BBD4 MSB	
		0x3C	BBD5 LSB	
		0x3C	BBD5 MSB	
		0x3C	BBD6 LSB	
		0x3C	BBD6 MSB	
		0x3C	BBD7 LSB	
		0x3C	BBD7 MSB	
		0x3C	BBD8 LSB	
		0x3C	BBD8 MSB	
		0x3C	BBD9 LSB	
		0x3C	BBD9 MSB	
		0x3C	BBD10 LSB	
		0x3C	BBD10 MSB	
		0x3C	BBD11 LSB	
		0x3C	BBD11 MSB	
		0x3C	BBD12 LSB	
		0x3C	BBD12 MSB	
		0x3C	BBD13 LSB	
		0x3C	BBD13 MSB	
		0x3C	BBD14 LSB	
		0x3C	BBD14 MSB	
		0x3C	BBD15 LSB	
		0x3C	BBD15 MSB	
		0x3C	BBD16 LSB	
		0x3C	BBD16 MSB	
		0x3C	BBD17 LSB	
		0x3C	BBD17 MSB	
		0x3C	BBD18 LSB	
		0x3C	BBD18 MSB	
		0x3C	BBD19 LSB	
		0x3C	BBD19 MSB	
		0x3C	BBD20 LSB	
		0x3C	BBD20 MSB	
		0x3C	BBD21 LSB	
		0x3C	BBD21 MSB	
		0x3C	BBD22 LSB	
		0x3C	BBD22 MSB	
		0x3C	BBD23 LSB	
		0x3C	BBD23 MSB	
		0x3C	BBD24 LSB	
		0x3C	BBD24 MSB	
		0x3C	BW0 LSB	Bin Weightings (BW0 – BW23) are 16bit unsigned integer variables.
		0x3C	BW0 MSB	
		0x3C	BW1 LSB	
		0x3C	BW1 MSB	
		0x3C	BW2 LSB	
		0x3C	BW2 MSB	
		0x3C	BW3 LSB	
		0x3C	BW3 MSB	
		0x3C	BW4 LSB	
		0x3C	BW4 MSB	
		0x3C	BW5 LSB	
		0x3C	BW5 MSB	
		0x3C	BW6 LSB	
		0x3C	BW6 MSB	
		0x3C	BW7 LSB	

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		0x3C	BW7 MSB	
		0x3C	BW8 LSB	
		0x3C	BW8 MSB	
		0x3C	BW9 LSB	
		0x3C	BW9 MSB	
		0x3C	BW10 LSB	
		0x3C	BW10 MSB	
		0x3C	BW11 LSB	
		0x3C	BW11 MSB	
		0x3C	BW12 LSB	
		0x3C	BW12 MSB	
		0x3C	BW13 LSB	
		0x3C	BW13 MSB	
		0x3C	BW14 LSB	
		0x3C	BW14 MSB	
		0x3C	BW15 LSB	
		0x3C	BW15 MSB	
		0x3C	BW16 LSB	
		0x3C	BW16 MSB	
		0x3C	BW17 LSB	
		0x3C	BW17 MSB	
		0x3C	BW18 LSB	
		0x3C	BW18 MSB	
		0x3C	BW19 LSB	
		0x3C	BW19 MSB	
		0x3C	BW20 LSB	
		0x3C	BW20 MSB	
		0x3C	BW21 LSB	
		0x3C	BW21 MSB	
		0x3C	BW22 LSB	
		0x3C	BW22 MSB	
		0x3C	BW23 LSB	
		0x3C	BW23 MSB	
		0x3C	M_A LSB	M_A (PM diameter A) is a 16bit unsigned integer variable representing diameter in um * 100.
		0x3C	M_A MSB	
		0x3C	M_B LSB	M_B (PM diameter B) is a 16bit unsigned integer variable representing diameter in um * 100.
		M_B MSB	M_B MSB	
		0x3C	M_C LSB	M_C (PM diameter C) is a 16bit unsigned integer variable representing diameter in um * 100.
		0x3C	M_C MSB	
		0x3C	MaxTOF LSB	MaxTOF (Maximum Time Of Flight) is a 16bit unsigned integer variable.
		0x3C	MaxTOF MSB	
		0x3C	AMSamplingIntervalCount LSB	AMSamplingIntervalCount is a 16bit unsigned integer variable.
		0x3C	AMSamplingIntervalCount MSB	
		0x3C	AMIdleIntervalCount LSB	AMIdleIntervalCount is a 16bit unsigned integer variable.
		0x3C	AMIdleIntervalCount MSB	
		0x3C	AMMaxDataArraysInFile LSB	AMMaxDataArraysInFile is a 16bit unsigned integer variable.
		0x3C	AMMaxDataArraysInFile MSB	
		0x3C	AMOnlySavePMData	AMOnlySavePMData is an 8bit unsigned integer variable.
		0x3C	AMFanOnInIdle	AMFanOnInIdle is an 8bit unsigned integer variable.

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		0x3C	AMLaserOnInIdle	AMLaserOnInIdle is an 8bit unsigned integer variable.
		0x3C	TOF to SFR factor	Time of Flight to Sample Flow Rate conversion factor' is an 8bit unsigned integer variable.
		0x3C	PVP	PVP (Particle Validation Period) is an 8bit unsigned integer variable.
		0x3C	BinWeightingIndex	BinWeightingIndex (0-9) is an 8bit unsigned integer that represents the index of the preset bin weightings to use.
Write Configuration Variables	**0x3A**	0x3A	0x31	Suggest that 10ms be used as delay between command byte and following byte.
		0x3A	0xF3	
		BB0 LSB	0x3A	Bin Boundaries ADC (BB0 – BB16) are 16bit unsigned integer variables.
		BB0 MSB	BB0 LSB	
		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	
		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	
		BB17 LSB	BB16 MSB	
		BB17 MSB	BB17 MSB	
		BB18 LSB	BB17 MSB	
		BB18 MSB	BB18 LSB	
		BB19 LSB	BB18 MSB	
		BB19 MSB	BB19 LSB	
		BB20 LSB	BB19MSB	
		BB20 MSB	BB20 LSB	
		BB21 LSB	BB20 MSB	
		BB21 MSB	BB21 LSB	
		BB22 LSB	BB21 MSB	
		BB22 MSB	BB22 LSB	

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		BB23 LSB	BB22 MSB	
		BB23 MSB	BB23 LSB	
		BB24 LSB	BB23 MSB	
		BB24 MSB	BB24 LSB	
		BBD0 LSB	BB24 MSB	Bin Boundaries diameter(um) (BBD0 – BBD24) are 16bit unsigned integer variables representing the diameter in um x100.
		BBD0 MSB	BBD0 LSB	
		BBD1 LSB	BBD0 MSB	
		BBD1 MSB	BBD1 LSB	
		BBD2 LSB	BBD1 MSB	
		BBD2 MSB	BBD2 LSB	
		BBD3 LSB	BBD2 MSB	
		BBD3 MSB	BBD3 LSB	
		BBD4 LSB	BBD3 MSB	
		BBD4 MSB	BBD4 LSB	
		BBD5 LSB	BBD4 MSB	
		BBD5 MSB	BBD5 LSB	
		BBD6 LSB	BBD5 MSB	
		BBD6 MSB	BBD6 LSB	
		BBD7 LSB	BBD6 MSB	
		BBD7 MSB	BBD7 LSB	
		BBD8 LSB	BBD7 MSB	
		BBD8 MSB	BBD8 LSB	
		BBD9 LSB	BBD8 MSB	
		BBD9 MSB	BBD9 LSB	
		BBD10 LSB	BBD9 MSB	
		BBD10 MSB	BBD10 LSB	
		BBD11 LSB	BBD10 MSB	
		BBD11 MSB	BBD11 LSB	
		BBD12 LSB	BBD11 MSB	
		BBD12 MSB	BBD12 LSB	
		BBD13 LSB	BBD12 MSB	
		BBD13 MSB	BBD13 LSB	
		BBD14 LSB	BBD13 MSB	
		BBD14 MSB	BBD14 LSB	
		BBD15 LSB	BBD14 MSB	
		BBD15 MSB	BBD15 LSB	
		BBD16 LSB	BBD15 MSB	
		BBD16 MSB	BBD16 LSB	
		BBD17 LSB	BBD16 MSB	
		BBD17 MSB	BBD17 LSB	
		BBD18 LSB	BBD17 MSB	
		BBD18 MSB	BBD18 LSB	
		BBD19 LSB	BBD18 MSB	
		BBD19 MSB	BBD19 LSB	
		BBD20 LSB	BBD19 MSB	
		BBD20 MSB	BBD20 LSB	
		BBD21 LSB	BBD20 MSB	
		BBD21 MSB	BBD21 LSB	
		BBD22 LSB	BBD21 MSB	
		BBD22 MSB	BBD22 LSB	
		BBD23 LSB	BBD22 MSB	
		BBD23 MSB	BBD23 LSB	
		BBD24 LSB	BBD23 MSB	
		BBD24 MSB	BBD24 LSB	
		BW0 LSB	BBD24 MSB	Bin Weightings (BW0 – BW23) are 16bit unsigned integer variables.
		BW0 MSB	BW0 LSB	
		BW1 LSB	BW0 MSB	
		BW1 MSB	BW1 LSB	
		BW2 LSB	BW1 MSB	

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		BW2 MSB	BW2 LSB	
		BW3 LSB	BW2 MSB	
		BW3 MSB	BW3 LSB	
		BW4 LSB	BW3 MSB	
		BW4 MSB	BW4 LSB	
		BW5 LSB	BW4 MSB	
		BW5 MSB	BW5 LSB	
		BW6 LSB	BW5 MSB	
		BW6 MSB	BW6 LSB	
		BW7 LSB	BW6 MSB	
		BW7 MSB	BW7 LSB	
		BW8 LSB	BW7 MSB	
		BW8 MSB	BW8 LSB	
		BW9 LSB	BW8 MSB	
		BW9 MSB	BW9 LSB	
		BW10 LSB	BW9 MSB	
		BW10 MSB	BW10 LSB	
		BW11 LSB	BW10 MSB	
		BW11 MSB	BW11 LSB	
		BW12 LSB	BW11 MSB	
		BW12 MSB	BW12 LSB	
		BW13 LSB	BW12 MSB	
		BW13 MSB	BW13 LSB	
		BW14 LSB	BW13 MSB	
		BW14 MSB	BW14 LSB	
		BW15 LSB	BW14 MSB	
		BW15 MSB	BW15 LSB	
		BW16 LSB	BW15 MSB	
		BW16 MSB	BW16 LSB	
		BW17 LSB	BW16 MSB	
		BW17 MSB	BW17 LSB	
		BW18 LSB	BW17 MSB	
		BW18 MSB	BW18 LSB	
		BW19 LSB	BW18 MSB	
		BW19 MSB	BW19 LSB	
		BW20 LSB	BW19 MSB	
		BW20 MSB	BW20 LSB	
		BW21 LSB	BW20 MSB	
		BW21 MSB	BW21 LSB	
		BW22 LSB	BW21 MSB	
		BW22 MSB	BW22 LSB	
		BW23 LSB	BW22 MSB	
		BW23 MSB	BW23 LSB	
		M_A LSB M_A MSB	BW23 MSB M_A LSB	M_A (PM diameter A) is a 16bit unsigned integer variable representing diameter in um * 100.
		M_B LSB M_B MSB	M_A MSB M_B LSB	M_B (PM diameter B) is a 16bit unsigned integer variable representing diameter in um * 100.
		M_C LSB M_C MSB	M_B MSB M_C LSB	M_C (PM diameter C) is a 16bit unsigned integer variable representing diameter in um * 100.
		MaxTOF Byte0 MaxTOF Byte1	M_C MSB MaxTOF Byte0	Max Time of Flight' is a 16bit unsigned integer variable.
		AMSamplingIntervalCount LSB AMSamplingIntervalCount MSB	MaxTOF Byte1 AMSamplingIntervalCount LSB	AMSamplingIntervalCount is a 16bit unsigned integer variable.

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		AMIdleIntervalCount LSB AMIdleIntervalCount MSB	AMSamplingIntervalCount MSB AMIdleIntervalCount LSB	AMIdleIntervalCount is a 16bit unsigned integer variable.
		AMMaxDataArraysInFile LSB AMMaxDataArraysInFile MSB	AMIdleIntervalCount MSB AMMaxDataArraysInFile LSB	AMMaxDataArraysInFile is a 16bit unsigned integer variable.
		AMOnlySavePMData	AMMaxDataArraysInFile MSB	AMOnlySavePMData is an 8bit unsigned integer variable.
		AMFanOnInIdle	AMOnlySavePMData	AMFanOnInIdle is an 8bit unsigned integer variable.
		AMLaserOnInIdle	AMFanOnInIdle	AMLaserOnInIdle is an 8bit unsigned integer variable.
		TOF to SFR factor	AMLaserOnInIdle	'Time of Flight to Sample Flow Rate conversion factor' is an 8bit unsigned integer variable.
		PVP	TOF to SFR factor	PVP (Particle Validation Period) is an 8bit unsigned integer variable.
Read histogram data (and reset histogram)	**0x30**	0x30 0x30	0x31 0xF3	Suggest that 10ms be used as delay between command byte and following byte.
		0x30 0x30	Bin0 LSB Bin0 MSB	Bin Counts (Bin0 - Bin23) are 16bit unsigned integer variables. 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	Bin16 LSB	
		0x30	Bin16 MSB	
		0x30	Bin17 LSB	
		0x30	Bin17 MSB	
		0x30	Bin18 LSB	
		0x30	Bin18 MSB	

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		0x30	Bin19 LSB	
		0x30	Bin19 MSB	
		0x30	Bin20 LSB	
		0x30	Bin20 MSB	
		0x30	Bin21 LSB	
		0x30	Bin21 MSB	
		0x30	Bin22 LSB	
		0x30	Bin22 MSB	
		0x30	Bin23 LSB	
		0x30	Bin23 MSB	
		0x30	Bin1 MToF	MToF' is an 8bit unsigned integer that represents the average amount of time that particles sized in the stated bin took to cross the OPS's laser beam. Each value is in 1/3 us. i.e. a value of 10 would represent 3.33us.
		0x30	Bin3 MToF	
		0x30	Bin5 MToF	
		0x30	Bin7 MToF	
		0x30	Sampling Period LSB	Sampling Period' is a 16bit unsigned integer and is a measure of the histogram's actual sampling period in seconds x100
		0x30	Sampling Period MSB	
		0x30	Sample Flow Rate LSB	Sample Flow Rate' is a 16bit unsigned integer variable that represents the sample flow rate in ml/s x100
		0x30	Sample Flow Rate MSB	
		0x30	Temperature LSB	Temperature is a 16bit unsigned integer.
		0x30	Temperature MSB	
		0x30	Relative humidity LSB	Relative humidity is a 16bit unsigned integer.
		0x30	Relative humidity MSB	
		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	Reject count Glitch LSB	Reject count Glitch' is a 16bit unsigned integer.
		0x30	Reject count Glitch MSB	
		0x30	Reject count LongTOF LSB	Reject count LongTOF' is a 16bit unsigned integer.
		0x30	Reject count LongTOF MSB	
		0x30	Reject count Ratio LSB	Reject count Ratio' is a 16bit unsigned integer.
		0x30	Reject count Ratio MSB	
		0x30	Reject count OutOfRange LSB	Reject count Ratio' is a 16bit unsigned integer.
		0x30	Reject count OutOfRange MSB	
		0x30	Fan rev count LSB	Fan rev count' is a 16bit unsigned integer.
		0x30	Fan rev count MSB	

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		0x30	Laser status LSB	Laser status' is a 16bit unsigned integer.
		0x30	Laser status MSB	
		0x30	Checksum LSB	Checksum is a 16bit unsigned integer.
		0x30	Checksum MSB	
Read PM data (and reset histogram)	**0x32**	0x32	0x31	Suggest that 10ms be used as delay between command byte and following byte.
		0x32	0xF3	
		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 a 16bit unsigned integer.
		0x32	Checksum Byte1	
Save Configuration Variables in non-volatile memory	**0x43**	0x43	0x31	Suggest that 10ms 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	

In response to any initial command byte, the OPC-N3 should return a byte of value 0x31, indicating it is busy.
Upon receiving a command byte OPC-N3 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-N3, the returned byte will continue to be 0x31 (busy). When the OPC-N3 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-N3. If it is not, the OPC-N3 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.

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To communicate with the OPC-N3, the SPI master should poll the OPC-N3 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-N3. 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-N3 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.

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4 Conversion of Signal Output from the temperature and humidity signal on the OPC N3

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.

5 Comment on Check Sum

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;
```


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```
    }
  }
  return crc;
}
```


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6 OPC-N3 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 24 size bins. Note the lower boundary of bin 0 and the higher of bin 23 are fixed. These are defined in ADV values and microns.
Bin weightings	Correction for size dependent sampling efficiency and density. The OPC-N3 has 9 preset indexes of weightings and one end user configurable index (index 0). Note these may be undefined on Beta release samples
Laser digital pot setting	A parameter to determine laser beam power.
Fan digital pot setting	A parameter to set fan power, default 255.

NOTE: Changing the laser power will change calibration and the OPC-N3 will require recalibration.
When the OPC-N3 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	December 2017	Mark Giles
B	Second Draft	February 2018	Mark Giles
C	Third Draft (Fw 1.16)	February 2018	Mark Giles
D	Fourth Draft (Fw 1.17 and flow chart correction)	May 2018	Mark Giles
1	Issue 1 (T and H)	August 2018	Mark Giles

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