AquaTroll 500

Interface Specification

Revision: 0.22

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Conventions

The terminology used for requirements is as follows:

Must/Shall

All requirements containing the words “Must” or “Shall” are mandatory and non-negotiable. These terms signify requirements that are essential to the inter-operation of the overall architecture.

Should/Recommended

All requirements containing the word “May” “Might” or “Should” are suggestions for standard behavior and design and should be considered necessary unless specific reasons are presented to ignore or disregard the suggestion. The implications of discarding suggested design requirements should be carefully considered.

Optional

All requirements listed as “Optional” are purely up to the discretion of the designer to implement.

Purpose

This document is the high-level interface specification for the In-Situ AquaTroll 500 Probe (both non-vented and vented versions). It is an extension to the In-Situ System Interface Specification, and defines the device-specific characteristics of the probe.

Overview

The AquaTroll 500 Probe is a multi-parameter water quality probe. It has integral depth and barometric pressure sensors and supports a variety of plug-in sensors including, but not limited to, RDO, conductivity, temperature, turbidity, pH and ORP. The probe supports the following interface standards.

1. MODBUS RS485. The device shall adhere to the specifications for probes and sensors as described in the In-Situ System Interface specification and the extensions described in this document.

2. MODBUS over Bluetooth. The device shall adhere to the specifications for probes and sensors as described in the In-Situ System Interface specification and the extensions described in this document.

3. SDI-12. The device shall adhere to the Serial Digital Interface Standard for Microprocessor-Based Sensors, Version 1.3 dated September 17, 2002 and the extensions to the specification described in this document.

MODBUS Reserved Registers

The device shall implement the full reserved register set identified in the System Interface Specifications. This section identifies device-specific values returned in the reserved registers.

Register Map Template Version

This register shall return the value 3.

Device Id

The device id shall return 33 for the non-vented version.

The device id shall return 34 for the vented version.

The functionality of the two devices shall be identical except for the barometric pressure measurement methodology.

Hardware Version

The valid range for the device hardware version shall be 0 to 15.

Hardware Version	Firmware Versions
3 – prototypes	0.10 – 1.XX
4 – new baro & log memory	0.13 – 1.XX

Max Data Logs

The maximum number of data logs supported is 0 (data logging is not supported).

Total Data Log Memory

The total data log memory is 0 bytes (data logging is not supported).

Total Battery Ticks

This register shall return 0 (an internal battery is not provided).

Last Battery Change

This register shall return a time value of 0 and shall be read-only (an internal battery is not provided).

Device Commands

The device-specific commands are specified below.

Id	Name	Access Level	Description
0xD100	Operate Wiper	3	Manual wiper operation. Resets the wiper interval. Exceptions:

Id	Name	Access Level	Description
			0x94 – Wiper port open 0x93 – Wiper not installed (wiper plug) 0x95 – Wiper current overload 0x97 – Wiper operation timeout
0xD104	Initiate radio firmware update	3	Initiate radio firmware update per manufacturer's protocol.

Current Time

The current UTC time is kept to the nearest second. The fractions portion of the current time register shall always return zero.

If the current UTC time is less than the manufacture date, indicating a loss of the time, writing to the time register shall update the internal UTC time and set the offset correction to zero. Otherwise, the internal UTC time shall not be modified by writing to the register. A write shall cause an offset correction to the internal UTC time to be calculated and stored. All subsequent reads and timestamps shall have the offset correction applied to the internal UTC time. The device shall set the internal UTC time to the manufacture time when the manufacture time is written at the factory access level.

Device Status

The device will set bit 15 of the standard device status (physical port open warning) if the wiper port or battery cover is open. The device supports the following device specific status values.

Device Status Bit Values

Bit	Category	Mask	Description	Cleared on Status Reset
16	Warning	0x00010000	Reserved	No
17	Warning	0x00020000	Wiper port open	No (note 1, 2)
18	Status	0x00040000	Wiper installed	No (note 2)
19	Warning	0x00080000	Wiper operation warning	Yes
20	Status	0x00100000	Reserved	No
21	Status	0x00200000	Reserved	No
22	Status	0x00400000	Reserved	No
23	Status	0x00800000	Reserved	No
24	Status	0x01000000	Reserved	No
25	Status	0x02000000	Reserved	No
26	Status	0x04000000	Reserved	No
27	Status	0x08000000	Reserved	No
28	Status	0x10000000	Reserved	No
29	Status	0x20000000	Reserved	No
30	Status	0x40000000	Reserved	No

Bit	Category	Mask	Description	Cleared on Status Reset
31	Status	0x80000000	Reserved	No

Note 1: These bits will also cause the standard port open status bit (bit 15) to be set.

Note 2: These bits are refreshed by reading the sensor connection status register.

Used Battery Ticks

This register shall always return zero (an internal battery is not provided).

Serial Communication Configuration

The standard communication control registers (9200 to 9209) shall apply to the RS485 interface. Operation of the Bluetooth interface shall not be affected by changes in these registers. The RS485 interface shall support the communication configurations specified in the table below.

Bits	Description
0	Modbus Transmission Mode 0 = RTU (default) 1=ASCII
1,2 & 3	Baud Rate Id 0 = 9600 1 = 19200 (default) 2 = 38400 3 = 57600
4	Data Bits 0 = 7 data bits 1 = 8 data bits (default)
5,6	Parity Bits 0 = Even (default) 1 = Odd 2 = None
7	Stop Bits 0 = 1 Stop Bit (default) 1 = 2 Stop Bits

Note: 7 data bits is not a valid setting for Modbus RTU communication. If an attempt is made to write RTU mode with 7 data bits, the device will return an exception with error code 0x84. All other combinations of communication configurations shall be supported.

Max Allowed Baud Rate Id

This register shall return a value of 3 (57600 baud).

Max Message/Response Size

The device shall have a maximum message and response size of 1024 bytes. Reading this value will return the maximum message size of the RS485 connection.

Device Address

The sonde shall support a broadcast read of its device address register.

Probe Connection Registers

Probe connection registers 9297 through 9299 are not supported since this device is not a controller. Any attempt to access these registers will return an exception response with exception code 2 (illegal data address).

Max Sensor Connections

This register will return a value of 5 to 7 depending on the factory configuration of the instrument.

Sensor Connection Status

Up to seven sensor connections are supported, represented by Bits 0 through 6 in the sensor connection register as defined in the tables below. The probe will detect its sensor configuration and respond within 2500 milliseconds.

Bit	Port	Sensor	AT500 Description
0	Port 1	Port 1	User installed, bit set when a sensor or plug is installed.
1	Port 2	Port 2	User installed, bit set when a sensor or plug is installed.
2	Port 3	Port 3	User installed, bit set when a sensor or plug is installed.
3	Port 4	Port 4	User installed, bit set when a sensor or plug is installed.
4	Port 5	Internal	Internal parameters, always installed, bit is always set.
5	Port 6	Level	Factory installed option, bit set if installed.

Bit	Port	Sensor	AT500V Description
0	Port 1	Port 1	User installed, bit set when a sensor or plug is installed.
1	Port 2	Port 2	User installed, bit set when a sensor or plug is installed.
2	Port 3	Port 3	User installed, bit set when a sensor or plug is installed.
3	Port 4	Port 4	User installed, bit set when a sensor or plug is installed.
4	Port 5	Internal	Internal parameters, always installed, bit is always set.
5	Port 6	Baro	Factory installed option, bit is always set.
6	Port 7	Level	Factory installed option, bit set if installed.

Sensor Map Registers

The sensor map registers are allocated per the following table. Attempts to access unused map registers will result in an exception response with exception code 0x02 (illegal data address).

Port	Map Registers	Data Register Offset
Port 1	9303 – 9307	1
Port 2	9308 – 9312	219
Port 3	9313 – 9317	437
Port 4	9318 – 9322	655
Port 5	9323 – 9327	873
Port 6	9328 – 9332	1091
Port 7	9333 – 9337	1309

Sensor Cache Timeout

The default value for this register shall be 10000 milliseconds. The cache timer has a resolution of one second. The cache timeout will be adjusted to be the smallest number of whole seconds not less than the specified value.

Interface Configuration

This register shall return a value of 225 (0x00E1) indicating that SDI-12, continuous readying, modem information, and calibration history file are supported. Win-Situ logging control is not supported.

A 4-20 mA current loop interface is not supported. Attempting to access current loop configuration registers 9501 through 9507 will result in an exception response with exception code 0x02 (illegal data address).

Internal Parameters Sensor

The internal parameters register is factory installed and always appears as sensor connection 7 (bit 6 in the sensor connection status register). The corresponding sensor data offset register points to the first register in the sensor data header block. All register values in this section are offsets from that base value.

Parameters provided by the internal sensor are considered “preferred.” If an internal parameter id is a duplicate of a parameter id provided by other sensors, the internal sensor parameter will provide the preferred representation of that parameter, allowing the other representations of the parameter to be ignored if desired.

Header Registers

Register	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
0	1	R1/W4	ushort	Sensor Id = 79
1	2	R1	ulong	Sensor serial number
3	1	R1	16 bits	Sensor status
4	3	R1/W4	time	Last factory calibration
7	3	R1/W4	time	Next factory calibration (0 = none required)
10	3	R1	time	Last user calibration
13	3	R1/W2	time	Next user calibration (0 = none required)
16	1	R1	ushort	Warm-up time = 400 milliseconds
17	1	R1	ushort	Fast sample rate = 400 milliseconds
18	1	R1	ushort	Number of sensor parameters (N) = 2
19	1	R1/W3	ushort	Alarm/warning parameter number (1 – N, default = 1)
20	1	R1/W3	16 bits	Alarm and warning enable bits (default = 0) Bit 0 = High alarm enabled Bit 1 = High warning enabled Bit 2 = Low warning enabled Bit 3 = Low alarm enabled Bit 4 = Sensor calibration warning
21	2	R1/W3	float	High alarm set value (default = 0.0)
23	2	R1/W3	float	High alarm clear value (default = 0.0)
25	2	R1/W3	float	High warning set value (default = 0.0)
27	2	R1/W3	float	High warning clear value (default = 0.0)
29	2	R1/W3	float	Low warning clear value (default = 0.0)
31	2	R1/W3	float	Low warning set value (default = 0.0)
33	2	R1/W3	float	Low alarm clear value (default = 0.0)
35	2	R1/W3	float	Low alarm set value (default = 0.0)

Parameter 1: Preferred Temperature

Register	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
37	2	R1	float	Measured value
39	1	R1	ushort	Parameter Id = 1 (temperature)
40	1	R1/W2	ushort	Units Id 1 = °C (default) 2 = °F
41	1	R1	ushort	Data Quality Id
42	2	R1/W3	float	Off line sentinel value (default = 0.0)
44	1	R1	16 bits	Available Units = 0x0003 (3)

The preferred temperature presents the most accurate temperature available from the set of sensors plugged into the instrument at the time. If a temperature sensor is not available, or the sensor temperature returns an error, the sonde will substitute its internal temperature sensor value and set the data quality id to a warning.

The sensor warm-up and fast sample rate registers will update to reflect those of the selected temperature sensor.

Sensors with temperature parameters are ranked as follows. A higher number indicates a higher preference, sensors of equal ranking are chosen in port order.

Temperature Sensor (Id 55): 7

Conductivity/Temperature Sensor (Id 56): 5

RWT Sensor (Id 60): 3

CHLA Sensor (Id 62): 3

BGA-PC Sensor (Id 64): 3

BGA-PE Sensor (Id 65): 3

Parameter 2: External Voltage

Register	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
45	2	R1	float	Measured value
47	1	R1	ushort	Parameter Id = 32 (external voltage)
48	1	R1/W2	ushort	Units Id 163 = Volts (default)
49	1	R1	ushort	Data Quality Id
50	2	R1/W3	float	Sentinel value (default = 0.0 V)
52	1	R1	16	Available Units = 0x0004 (4)

Register	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
			bits	

Barometric Pressure Sensor

The barometric pressure sensor is only available on the AT500V. It is factory installed and appears as sensor connection 5 (bit 4 in the sensor connection status register). The corresponding sensor data offset register points to the first register in the sensor data header block. All register values in this section are offsets from that base value. Measuring the barometric sensor does not trigger the wiper.

Header Registers

Register	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
0	1	R1/W4	ushort	Sensor Id = 59
1	2	R1	ulong	Sensor serial number
3	1	R1	16 bits	Sensor status
4	3	R1/W4	time	Last factory calibration
7	3	R1/W4	time	Next factory calibration (0 = none required)
10	3	R1	time	Last user calibration
13	3	R1/W2	time	Next user calibration (0 = none required)
16	1	R1	ushort	Warm-up time = 300 milliseconds
17	1	R1	ushort	Fast sample rate = 300 milliseconds
18	1	R1	ushort	Number of sensor parameters (N) = 1
19	1	R1/W3	ushort	Alarm/warning parameter number (1 – N, default = 1)
20	1	R1/W3	16 bits	Alarm and warning enable bits (default = 0) Bit 0 = High alarm enabled Bit 1 = High warning enabled Bit 2 = Low warning enabled Bit 3 = Low alarm enabled Bit 4 = Sensor calibration warning
21	2	R1/W3	float	High alarm set value (default = 0.0)
23	2	R1/W3	float	High alarm clear value (default = 0.0)
25	2	R1/W3	float	High warning set value (default = 0.0)

Register	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
27	2	R1/W3	float	High warning clear value (default = 0.0)
29	2	R1/W3	float	Low warning clear value (default = 0.0)
31	2	R1/W3	float	Low warning set value (default = 0.0)
33	2	R1/W3	float	Low alarm clear value (default = 0.0)
35	2	R1/W3	float	Low alarm set value (default = 0.0)

Parameter 1: Barometric Pressure

Register	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
37	2	R1	float	Measured value, P_B
39	1	R1	ushort	Parameter Id = 16 (barometric pressure)
40	1	R1/W2	ushort	Units Id 17 = PSI 19 = KPa 20 = bar 21 = mbar 22 = mmHg (default) 24 = cmH_2O 25 = in H_2O
41	1	R1	ushort	Data Quality Id
42	2	R1/W3	float	Sentinel value (default = 760.0 mmHg)
44	1	R1	16 bits	Available Units = 0x01FD (509)

For the vented instrument, the measured barometric pressure (P_B) is calculated as:

$P_B = B_S + B_O$

Where B_S is the factory calibrated barometric pressure and B_O is the user offset calibration, all in the current units. The barometric pressure can be measured at any time; the value contained in the probe's live barometric pressure register is ignored.

For the non-vented instrument, the barometric pressure (P_B) is the probe's live barometric pressure register as written by the master device. If the master device does not provide live barometric pressure, the default barometric pressure will be used.

Pressure is measured in mbar. Conversion to other units is as follows.

KPa = 6.894757 * PSI

bar = 0.06894757 * PSI

mbar = 68.94757 * PSI

mmHg = 51.71492 * PSI

inHg = 2.036021 * PSI

cmH_2O = 70.30696 * PSI

inH_2O = 27.67990 * PSI

Calibration Registers

Values in the calibration registers determine how sensor parameters are calculated.

Register	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
117	2	R1/W3	float	Vented: Barometric Offset, B_O (default = 0.0) Non-vented: Default Barometric Pressure (760 mmHg)

Calibration Procedure

The procedure to calibrate barometric pressure shall be as follows. The procedure is used to match open air readings to a barometric reference.

1. Write the Calibration On command (0xE000) to the sensor command register. Reading the barometric pressure parameter in the calibration mode shall present the barometric pressure with the current user calibration applied (P_B).
2. Read the barometric pressure parameter P_B and external barometric pressure reference B_R.
3. Compute the barometric offset as $B_O = B_R - P_M$ and write the offset to the barometric offset register, all in the current units. Internally, the new offset is added to the old offset. If the resulting offset is greater than +/-10 mbar, the probe will return an exception response with error code 0x97 indicating an invalid calibration. If valid, the calibration is in effect immediately but not yet permanently.
4. Write the Calibration Update command (0xE001) to the sensor command register. The sensor sets the last user calibration date to the current date and sets the next user calibration date, if not zero, to the current date plus the

previous next calibration interval. For a non-vented unit, saves the last calibrated reading as the last measurement taken.

5. Optionally, read the last user calibration time, add the next calibration interval, and write the result to the next user calibration time register.
6. Write the Calibration Off command (0xE002) to the sensor command register to place the sensor in normal operation.

Level Sensor

The level sensor is a factory installed option. If installed, it appears as sensor connection 6 (bit 5 in the sensor connection status register). The corresponding sensor data offset register points to the first register in the sensor data header block. All register values in this section are offsets from that base value. The level sensor functions the same as on the AT600. Refer to the AT600 Interface Specification document for sensor register details.

Plug-in Sensors

The AT500 supports the same sensors, wiper, and port plugs as the AT600. Refer to the AT600 Interface Specification document for sensor register details.

Probe Registers

Register	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
7000	1	R1	ushort	Probe Register Map Template Version (1)
7001	1	R1	ushort	External Power Voltage (millivolts)
7003	2	R1/W3	ulong	Wiper Interval, 15 to 86400 seconds (default = 3600)
7005	2	R1/W3	float	Live Barometric Pressure (mbar) AT500 only
7007	2	R1/W3	float	Default Barometric Pressure (mbar) AT500 only

Wiper Interval

This register determines shortest time interval (in seconds) that the wiper will be allowed to operate. If the sample rate is faster than this value, whether by logging or live readings, the wiper will only wipe at this interval. If the sample rate is longer than this interval, the wiper will wipe at the sample rate. If a log or live reading is requested within 15 seconds of the wiper interval, a wiper cycle will be triggered.

A wiper cycle consists of one complete revolution. Each revolution of the wiper will be in the opposite direction. A clockwise revolution will be followed by a counterclockwise revolution, etc.

Live Barometric Pressure

The live barometric pressure register allows an external controller to provide live barometric pressure readings to a non-vented instrument. Value must be written in millibars in the range 506.625 to 1114.675 mbar. Reading this register returns the most recently written external value. When the device power is cycled, this register is initialized with the contents of the

default barometric pressure register. This register is only available on a non-vented device. Any parameter on a non-vented device that requires barometric pressure in its calculations obtains the barometric pressure from this register.

Default Barometric Pressure

The contents of the default barometric pressure register are used to initialize the contents of the live barometric pressure register whenever the device is power cycled. The value is non-volatile and must be written in millibars in the range 506.625 to 1114.675 mbar. The factory default value is 1013.25 mbar. Writing this register also reinitializes the value of the live barometric pressure register. This register is only available on a non-vented device.

Modbus PLC Interface

The standard Modbus interface described in the previous sections, dynamically maps sensor parameter registers based on their physical port position in the Sonde. The standard interface is very flexible and adapts easily to a wide variety of sensor configurations; however, it has the adverse effect of causing parameter registers to move within the register map if the sensor configuration changes. There are many features in the standard interface that enable a Modbus master device to discover the parameter register locations.

The Modbus PLC Interface places parameter registers at fixed register locations based on the parameter id. This interface reduces programming complexity and removes the dependency on the sensor configuration. There are some system limitations when using this interface.

- Only one sensor of any sensor model should be used in the sonde (for example, only one turbidity sensor should be plugged in).
- If a parameter is provided by more than one of the installed sensors, the parameter can only be read from the first sensor in the port order.
- Only parameter measurement registers are supported. Configuration and calibration registers are not accessible using this interface (the standard interface must be used instead).

Parameter Discovery

The first register read in a PLC measurement sequence should be a 14-register block read beginning with register number 6984. The read of these registers triggers the sonde to scan its sensor ports and update its sensor map. This guarantees that the sonde has properly registered any changes to the sensor configuration that a user may have made since the last measurement sequence. The bitwise contents of these registers indicate which parameter ids (1 to 219) are currently available from the sonde according to the table below.

Refer to the sensor parameter sections for a description of the parameter ids.

Parameter Id Map					
	Bit				
Register	15	14	13…2	1	0
6984	16	15	14…3	2	1
6985	32	31	30…19	18	17
6986	48	47	46…35	34	33
6987	64	63	62…51	50	49

Parameter Id Map					
6988	80	79	78…67	66	65
6989	96	95	94…83	82	81
6990	112	111	110…99	98	97
6991	128	127	126…115	114	113
6992	144	143	142…131	130	129
6993	160	159	158…147	146	145
6994	176	175	174…163	162	161
6995	192	191	190…179	178	177
6996	208	207	206…195	194	193
6997	0	0	219…211	210	209

Reading Parameters

To determine the starting register number for a given parameter register block, first determine its parameter id by looking in the sensor's parameter tables. Then calculate the starting register number of the parameter block using the following equation.

Starting Register = (Parameter Id – 1) x 7 + 5451

For example, for the Conductivity Sensor, the parameter id for specific conductivity is 10 (bit 9 will be set in register 6984 if it is available). The starting register number for the specific conductivity register block is thus (10 – 1) x 7 + 5451 = 5514.

The starting register for each parameter points to a block of 7 registers that contain the following information.

Register Offset	Size (registers)	Mode & Access Level (R/W)	Data Type	Description
0	2	R1	float	Measured value
2	1	R1	ushort	Data Quality Id
3	1	R1/W2	ushort	Units Id
4	1	R1	ushort	Parameter Id
5	2	R1/W3	float	Off line sentinel value

Continuing with the above example, to measure and read specific conductivity, read the two-register floating point value at register 5514 (starting register 5514 + offset 0 = register 5514). To read the corresponding data quality id, read register 5516 (starting register 5514 + offset 2 = register 5516). Block reads within the parameter block are allowed. The specific conductivity can be measured and read along with its data quality id by reading the 3 registers starting at register 5514, then extracting the measured float value and the data quality id.

Registers within the block that are marked as read/write, can be written as well as read. Refer to the sensor-specific parameter information for valid values.

SDI-12 Interface

The device shall adhere to the Serial-Digital Interface Standard for Microprocessor-Based Sensors, Version 1.3 dated September 17, 2002, and the extensions to the specification identified in this document. This section identifies the device-specific implementation of the standard.

Configuration File

The device shall adhere to the specifications for writing and reading an SDI-12 configuration file as identified in the In-Situ System Interface Specification.

After the configuration file is written, sensors may be exchanged with sensors of the same type, and do not need to stay in their original port.

Power Management

When the device display turns off during SDI-12 operation, it enters a slightly higher sleep power state that permits faster wake times. This can compensate for SDI-12 data recorders that may not meet the 100 ms wake delay required by the SDI-12 specification.

Basic Command Implementation

The following table lists each basic SDI-12 command, its format, and the format of each response.

Name	Command	Response
Address Query	?!	a<CR><LF> The wildcard address '?' character is only supported for the Address Query command. It shall be ignored as an invalid address for all other commands.
Acknowledge Active	a!	a<CR><LF> The device supports the basic address characters in the range '0' to '9' and the extended address characters in the ranges 'A' to 'Z' and 'a' to 'z'. All other characters are ignored as an invalid address. The default address is '0'.
Change Address	aAb!	b<CR><LF> The device supports software changeable addresses.
Send Identification	aI!	a13IN-SITU AT600 vvv xxxxxx<CR><LF> or a13IN-SITU AT600Vvvv xxxxxx<CR><LF>

Name	Command	Response
		vvv = device firmware version * 100 (120 = 1.20) xxx = 6-digit device serial number with leading zeroes
Start Verification	aV!	a0033<CR><LF> Three values are available for reading by the Send Data command within 3 seconds. A service request (a<CR><LF>) will be sent when the values are ready.
Send Data	aD0!	a+n+u+s<CR><LF> n = lower 16 bits (0-65535) of the device status u = upper 16 bits (0-65535) of the device status s = lower 16 bits (0-65535) of the sensor connection status register
Additional Data	aD1! … aD9!	a<CR><LF> No values are returned after an additional data command.
Start Measurement Start Measurement CRC	aM! aMC!	a015n<CR><LF> n parameters (1 to 9) will be available for reading by the Send Data command within 15 seconds. A service request (a<CR><LF>) will be sent when the parameters are ready. The number of parameters returned and their order is determined by the SDI-12 configuration file. If the device is configured to output more than 9 parameters, only the first 9 parameters can be measured by this command.
Send Data	aD0!	a<values><CR><LF> or a<values><CRC><CR><LF>

Name	Command	Response
Additional Data	aD1! .. aD9!	At most 3 parameters are returned in a send data command. If more than 3 parameters are available, they are returned using the additional data command. A value of -99999 indicates that an expected sensor was missing. a<values><CR><LF> or a<values><CRC><CR><LF> At most 3 parameters are returned per additional data request.
Additional Measurements Additional with CRC	aM1! … aM9! aMC1! … aMC9!	a0000<CR><LF> or a015n<CR><LF> If the device is configured to output more than 9 parameters, each additional measurement command provides up to an addition 9 parameters.
Send Data Additional Data	aD0! aD1! … aD9!	a<values><CR><LF> or a<values><CRC><CR><LF> At most 3 parameters are returned per additional data request.

Extended Command Implementation

The device shall support the following extended SDI-12 commands.

Name	Command	Response
Auto Configure	aXAC!	a0051<CR><LF> One result is available within 5 seconds for reading by the Send Data command. Automatically creates an SDI-12 configuration file consisting of all parameters of all sensors beginning with port 1, up to a maximum of 30 parameters. A service request will be sent when the results are ready.
Send Data	aD0!	a+p<CR><LF>

Name	Command	Response
		p = number of parameters configured, 0 = command failed.
Set Factory Defaults	aXFD!	a0901<CR><LF> One result is available within 90 seconds for reading by the Send Data command. Restores all settings and calibration values to their factory defaults. A service request will be sent when the result is ready.
Send Data	aD0!	a+s<CR><LF> s = command status, 1 = command successful, 0 = command failed.
Communication Diagnostics	aXCD!	a0012<CR><LF> Two results are available within 1 second for reading by the Send Data command. A service request will be sent when the results are ready.
Send Data	aD0!	a+A+C<CR><LF> A = contents of Modbus device address register 49200, C = contents of Modbus serial communication configuration register 49201.