RDO Blue
Interface Specification

Revision: 1.00

221 East Lincoln Avenue, Fort Collins, CO 80524 USA
1-800-446-7488 (Toll-free in U.S.A. and Canada)
1-970-498-1500 (U.S.A. and International)
www.in-situ.com

Table of Contents

1. Revision History

Date	Revision	Author	Description
01/19/2020	1.00	Duane McKee	Initial Release

2. Introduction

This document describes the interface to the RDO Blue probe. It is an extension to the ISI System Interface Specification, describing instrument-specific aspects of the system interface.

3. Electrical Interface

The electrical interface consists of four connections: two power and two signal connections. Each connection is identified by a name on the board next to its solder pad.

3.1. Power Connections

GND is the zero-volt power and signal ground input supplied by the connected controller.

PWR is the power input supplied by the connected controller.

- The input voltage range is 8 to 36 volts DC as measured at the circuit board. The voltage supplied by the controller must be high enough to deliver the required voltage considering the cable length, wire size, and supply currents.

- The maximum current drawn by the instrument during measurements is 20 mA at 9 volts, 15 mA at 12 volts, and 10 mA at 24 volts.

- The maximum current drawn by the instrument when sleeping (not actively measuring or communicating) is 2 mA at 9 volts, 1.5 mA at 12 volts, and 1 mA at 24 volts.

- Power to the instrument may be switched on and off to help extend the battery life of the controller. The instrument is ready to accept commands 600 milliseconds after power is applied.

3.2. Signal Connections

The instrument utilizes an RS485 (EIA-485) compatible two-wire, bidirectional, half-duplex serial interface.

RB+ is the RS485B+ positive or non-inverting signal of the RS485 differential signal pair.

RA- is the RS485A- negative or inverting signal of the RS485 differential signal pair.

Note: The A and B signal descriptions used here are those described in the RS485 standard. The A/B signal naming used by many transceiver manufacturers is opposite that of the standard. The polarity of the inverting and non-inverting signals between the instrument and the controller must be matched correctly for proper operation.

- The maximum common mode input voltage range during normal operation is +/-20 volts DC.

- The maximum sustained input voltage range during fault conditions +/-36 volts DC.

- The instrument does not provide a termination resistor between the signal lines.

- The maximum point-to-point cable length is 4000 feet (1200 meters). Baud rates up to 19200 will provide reliable communication with an unterminated cable of this length. Operation at faster baud rates will require a shorter cable length or the addition of a termination resistor at both ends of the cable.

4. Modbus Interface

The instrument is a probe with an integral sensor. It conforms to the specifications for Probes and Sensors as identified in the ISI System Interface Specification. This section identifies the instrument-specific implementations of the standard.

4.1. Reserved Register Set

The instrument implements the full reserved register set. This section defines the instrument-specific values returned in the reserved registers.

4.1.1. Register Map Version

This register returns the value 3, indicating that the instrument supports version 3 of the ISI System Interface.

4.1.2. Device Id

The device id returns the value 35.

4.1.3. Serial Number

By default, the ISI assigned serial number is returned. If a non-zero OEM serial number is specified in the OEM configuration file, the OEM serial number will be returned instead. The serial number returned in the Slave Id response follows the same rule.

4.1.4. Manufacture Date

The manufacture date returns the ISI manufacture date of the instrument in UTC.

4.1.5. Hardware Version

The valid range for the hardware version is 0 to 15. Firmware updates may be limited to a range of hardware versions as identified in the following table.

Hardware Version	Firmware Versions
0	1.00 – 1.xx

4.1.6. Maximum Data Logs

Data logging is not supported. This register returns 0.

4.1.7. Total Data Log Memory

Data logging is not supported. This register returns 0.

4.1.8. Total Battery Ticks

The instrument does not have an internal battery. This register returns 0.

4.1.9. Last Battery Change

The instrument does not have an internal battery. This register returns 0 and is read-only.

4.1.10. Current Time

The current time in UTC is kept to the nearest second. The fractions portion of the current time register will always return zero. Writes to the current time register generate an offset correction from the internal UTC time but do not change the internal UTC time.

4.1.11. Used Battery Ticks

The instrument does not have an internal battery. This register returns 0.

4.1.12. Used Data Log Memory

Data logging is not supported. This register returns 0.

4.1.13. Active Log File Number

Data logging is not supported. This register returns 0.

4.1.14. Active Log File Status

Data logging is not supported. This register returns 0.

4.1.15. Device Address

The device Modbus address can range from 1 to 247. The ISI default address is 1. The default address can be specified in the OEM configuration file, in which case the OEM default setting will be restored when a factory defaults command is issued.

4.1.16. Serial Communication Configuration

The device supports the communication configurations specified in the table below. The defaults shown below are the ISI defaults that will be restored when a factory defaults command is issued. The default settings can be overridden in the OEM configuration file, in which case the OEM default settings will be restored when a factory defaults command is issued.

Register Bits	Description
0	Modbus Transmission Mode 0 = RTU (default) 1 = ASCII
1-3	Baud Rate Id 0 = 9600 1 = 19200 (default) 2 = 38400 3 = 57600
4	Data Bits 0 = 7 bits 1 = 8 bits (default)
5-6	Parity 0 = Even (default) 1 = Odd 2 = None
7	Stop Bits 0 = 1 bit (default) 1 = 2 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 are supported.

4.1.17. Maximum Allow Baud Rate Id

This register returns a value of 3 (57600 baud).

4.1.18. Maximum Message Size

The maximum message size is 1024 bytes.

4.1.19. Maximum Connections

The instrument is configured as a probe with one sensor that is permanently connected. This register returns a value of 1.

4.1.20. Connection Status

This register always returns a value of 1 (bit 0 set to indicate that sensor 1 is connected).

4.1.21. Sensor Map Registers

The sensor is mapped to probe connection 1 (registers 49303-49307). The instrument will respond with exception code 0x02, an invalid address, to all other sensor connection registers. The sensor supports register map version 1 and has a data register offset of 1.

4.1.22. Sensor Cache Timeout

The sensor cache timeout can range from 0 to 60000 milliseconds. The ISI default value for this register is 5 seconds. The default setting can be overridden in the OEM configuration file, in which case the OEM default setting will be restored when a factory defaults command is issued.

4.1.23. Interface Configuration

This register returns a value of 0x0000 (0) indicating that no special interfaces are supported.

4.1.24. Last Logged Record Registers

Data logging is not supported. The instrument will respond with exception code 0x02, an invalid address, to any attempt to access these registers.

5. RDO Sensor

The RDO sensor is a fixed sensor in the instrument, always appearing as sensor connection 1 and always with a sensor data offset of 1. Register values in this section are shown as absolute register values.

5.1. Header Registers

Register	Size	Access	Type	Description
40001	1	R1	ushort	Sensor Id = 42
40002	2	R1	ulong	Sensor Serial Number
40004	1	R1	ushort	Sensor Status
40005	3	R1	time	Last Factory Calibration
40008	3	R1	time	Next Factory Calibration (0 = none required)
40011	3	R1	time	Last User Calibration
40014	3	R1/W2	time	Next User Calibration (0 = none required)
40017	1	R1	ushort	Warm-up Time = 2000 ms
40018	1	R1	ushort	Fast Sample Rate = 1000 ms
40019	1	R1	ushort	Number of Sensor Parameters (N) = 5
40020	1	R1/W3	ushort	Alarm Parameter Number (1-N, default = 1)
40021	1	R1/W3	ushort	Alarm Enable Bits (default = 0) Bit 0 = High Alarm Enable Bit 1 = High Warning Enable Bit 2 = Low Warning Enable Bit 3 = Low Alarm Enable Bit 4 = Calibration Warning Enable
40022	2	R1/W3	float	High Alarm Set Value (default = 0.0)
40024	2	R1/W3	float	High Alarm Clear Value (default = 0.0)
40026	2	R1/W3	float	High Warning Set Value (default = 0.0)
40028	2	R1/W3	float	High Warning Clear Value (default = 0.0)
40030	2	R1/W3	float	Low Warning Clear Value (default = 0.0)
40032	2	R1/W3	float	Low Warning Set Value (default = 0.0)
40034	2	R1/W3	float	Low Alarm Clear Value (default = 0.0)
40036	2	R1/W3	float	Low Alarm Set Value (default = 0.0)

5.1.1. Sensor Serial Number

This field returns the serial number of the installed RDO cap. Zero is returned if the cap is not installed.

5.1.2. Last Factory Calibration

This field returns the start time of the installed RDO cap. If the cap has not been used, the cap manufacture date is returned. Zero is returned if the cap is not installed.

5.1.3. Next Factory Calibration

This field returns the expiration time of the installed RDO cap. Zero is returned if the cap is not installed.

5.2. Parameter 1: DO Concentration

DO concentration is calculated from the oxygen partial pressure and temperature using settings contained in the sensor calibration registers.

Register	Size	Access	Type	Description
40038	2	R1	float	Measured Value, C_0
40040	1	R1	ushort	Parameter Id = 20
40041	1	R1/W2	ushort	Unit Id 117 = mg/L (default) 118 = ug/L
40042	1	R1	ushort	Data Quality Id
40043	2	R1/W3	float	Sentinel Value (default = 0.0)
40045	1	R1	ushort	Available Units = 0x0030 (48)

The available units, the default unit id, and the default sentinel value can be overridden by the OEM configuration file.

DO concentration is internally calculated in mg/L. Conversion to other units is as follows.

$$\mu g/L = 1000 * mg/L$$

Oxygen concentration C_0 (mg/L) is calculated as follows:

$$C_0 = 31.9988 \times 1E6 \times \frac{\rho \, P_0}{k_0 M} (1 - \theta_0) \times S_C$$

Where:

P_0 is the partial pressure of O2 in atmospheres

$$P_{torr} = 759.999876 \times P_{atm}$$

Salinity correction:

Ln(Sc) = S(B0 + B1Ts + B2Ts^2 + B3Ts^3) + C0S^2

B0 = -6.246090E-003
B1 = -7.423444E-003
B2 = -1.048635E-002
B3 = -7.987907E-003
C0 = -4.679983E-007

Ts is the scaled temperature
Ts = ln [(298.15 – t) / (273.15 + t)]
where t is temperature in °C
S is the salinity in psu

Henry's constant:

$$\ln k_0 = 3.71814 + (5596.17/T) - (1{,}049{,}668/T^2)$$

T is temperature in degrees Kelvin.

Negative of the second pressure coefficient.

$$\theta_0 = 0.000975 - (1.426 \times 10^{-5} t) + (6.436 \times 10^{-8} t^2).$$

t is temperature in degrees C.

Density of Water:

$$\ln \rho = -0.589581 + (326.785/T) - (45{,}284.1/T^2)$$

T is in Kelvin

Molar mass of water.

$$M = 18.0152$$

References:

Benson and Krause, Jr.
The concentration and isotopic fractionation of gases dissolved in freshwater in equilibrium with the atmosphere.
Limnol, Oceanogr, 25(4), 1980, 662-671

Gordon and Garcia
Oxygen Solubility in Seawater: Better Fitting Equations
Limnol, Oceaongr, 37(6), 1992, 1307-1312

5.3. Parameter 2: Temperature

Register	Size	Access	Type	Description
40046	2	R1	float	Measured Value
40048	1	R1	ushort	Parameter Id = 1
40049	1	R1/W2	ushort	Unit Id 1 = °C (default) 2 = °F
40050	1	R1	ushort	Data Quality Id
40051	2	R1/W3	float	Sentinel Value (default = 0.0)
40053	1	R1	ushort	Available Units = 0x0003 (3)

The available units, the default unit id, and the default sentinel value can be overridden by the OEM configuration file.

Temperature is factory calibrated in °C. Conversion to other units is as follows.

$$°F = 1.8 * °C + 32$$

5.4. Parameter 3: DO Saturation

Register	Size	Access	Type	Description
40054	2	R1	float	Measured Value
40056	1	R1	ushort	Parameter Id = 21
40057	1	R1/W2	ushort	Unit Id 177 = % saturation (default)
40058	1	R1	ushort	Data Quality Id
40059	2	R1/W3	float	Sentinel Value (default = 0.0)
40061	1	R1	ushort	Available Units = 0x0001 (1)

The available units, the default unit id, and the default sentinel value can be overridden by the OEM configuration file.

RDO %Sat equations:

$$O_2\%Sat = \frac{O_2\text{Reading}}{O_2100\%Sat}$$

Where:

O_2 Reading is the mg/l reading from the RDO sensor.
O_2 100% Sat is the theoretical saturation value in mg/l and is derived as:

$$O_2100\%Sat = 31.9988\times10^6 \times \frac{\rho\left[0.20946\times\left(P - P_{wv}\right)\right]}{k_0 M}(1-\theta_0 P)\times S_C$$

Where:

ρ is the density of water in g/cm3:

$$\ln\rho = -0.589581 + (326.785/T) - (45{,}284.1/T^2)$$

T is the temperature in Kelvin degrees.

P is the atmospheric pressure in atm.

P_{wv} is the partial pressure of water vapor at saturation in atm.

$$\ln P_{wv} = 11.8571 - (3{,}840.70/T) - (216{,}961/T^2)$$

k_0 is Henry's constant:

$$\ln k_o = 3.71814 + (5596.17/T) - (1{,}049{,}668/T^2)$$

T is the temperature in Kelvin degrees.

M is the molar mass of water in g/mole

$$M = 18.0152$$

θ_0 is the Negative of the second pressure coefficient.

$$\theta_o = 0.000975 - (1.426 \times 10^{-5} t) + (6.436 \times 10^{-8} t^2).$$

t is temperature in degrees C.

S_C is the salinity correction:

ln Sc = S(B0 + B1Ts + B2Ts^2 + B3Ts^3) + C0S^2

B0 = -6.246090E-003
B1 = -7.423444E-003
B2 = -1.048635E-002
B3 = -7.987907E-003
C0 = -4.679983E-007

Ts is the scaled temperature
Ts = ln [(298.15 – t) / (273.15 + t)]
where t is temperature in °C
S is the salinity in psu

Per Standard Methods 4500-O(c), also see
Benson and Krause, Jr.
The concentration and isotopic fractionation of gases dissolved in freshwater in equilibrium with the atmosphere.
Limnol, Oceanogr, 25(4), 1980, 662-671

5.5. Parameter 4: Oxygen Partial Pressure

Register	Size	Access	Type	Description
40062	2	R1	float	Measured Value
40064	1	R1	ushort	Parameter Id = 30
40065	1	R1/W2	ushort	Unit Id 26 = torr (default)
40066	1	R1	ushort	Data Quality Id
40067	2	R1/W3	float	Sentinel Value (default = 0.0)
40069	1	R1	ushort	Available Units = 0x0200 (512)

The available units, the default unit id, and the default sentinel value can be overridden by the OEM configuration file.

5.6. Parameter 5: External Voltage

Register	Size	Access	Type	Description
40070	2	R1	float	Measured Value
40072	1	R1	ushort	Parameter Id = 32
40073	1	R1/W2	ushort	Unit Id 163 = volts (default)
40074	1	R1	ushort	Data Quality Id
40075	2	R1/W3	float	Sentinel Value (default = 0.0)
40076	1	R1	ushort	Available Units = 0x0004 (4)

The available units, the default unit id, and the default sentinel value can be overridden by the OEM configuration file.

5.7. Supported Cap Types

The following RDO cap types are supported and have the specified behavior.

5.7.1. Classic Cap

The expiration time is the lesser of the cap manufactured time plus 3 years, or the cap start time plus 15 months. An expired cap generates a factory calibration error data quality and supplies the sentinel value. By default, the cap wear algorithm is applied; however, the wear algorithm can be disabled in the OEM configuration file. A worn cap will generate a warning data quality with the measured DO value.

5.7.2. PRO-X Cap

The expiration time is the start time of the cap plus 2 years. An expired cap generates a warning data quality with the measured DO value. By default, the cap wear algorithm is applied; however, the wear algorithm can be disabled in the OEM configuration file. A worn will generate a warning data quality with the measured DO value.

5.7.3. Fast Cap

The expiration time is the start time of the cap plus 1 year. An expired cap generates a warning data quality with the measured DO value. The cap wear algorithm is not applied.

5.8. Calibration Registers

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

Register	Size	Access	Type	Description
40118	2	R1/W3	float	Live Salinity Value, PSU
40120	2	R1/W3	float	Default Salinity Value, PSU (default = 0.0)
40122	2	R1/W3	float	Live Barometric Pressure, mbar
40124	2	R1/W3	float	Default Barometric Pressure, mbar (default = 1013.25)
40126	2	R1/W3	float	100% Saturation Concentration, mg/L
40128	2	R1/W3	float	100% Saturation Temperature, °C
40130	2	R1/W3	float	100% Saturation Salinity, PSU
40132	2	R1/W3	float	100% Saturation Barometric Pressure, mbar
40134	2	R1/W3	float	0% Saturation Concentration, mg/L

40136	2	R1/W3	float	0% Saturation Temperature, °C
40138	2	R1/W3	float	Calibration Slope (default = 1.0)
40140	2	R1/W3	float	Calibration Offset (default = 0.0)
40142	1	R1/W3	ushort	Calibration Status (default = 0)

5.8.1. Live Salinity Value

The live salinity value is used to correct the oxygen concentration value for salinity. Values must be written in Practical Salinity Units (PSU). The normal range for salinity is 0 to 42 PSU; however live salinity can be written up to 2500 PSU to accommodate specialized applications. The maximum allowed salinity value can be overridden by the OEM configuration file. The live salinity register is initialized to the default salinity register when power is applied to the instrument or when the default salinity is changed. This is not a measured parameter.

5.8.2. Default Salinity Value

The default salinity value is loaded into the live salinity value register when power is applied to the instrument or when the default salinity is changed. The default salinity value is used in calculations until a live salinity value is written. The normal range for salinity is 0 to 42 PSU; however live salinity can be written up to 2500 PSU to accommodate specialized applications. The default salinity and the maximum allowed salinity value can be overridden by the OEM configuration file. This is not a measured parameter.

5.8.3. Live Barometric Pressure

The live barometric pressure is used in the calculation of percent saturation and to determine the theoretical saturation point during calibration. Values must be written in millibars in the range 506.625 to 1114.675 mbar. The live barometric pressure register is initialized to the default barometric pressure register when power is applied to the instrument or when the default barometric pressure is changed. This is not a measured parameter.

5.8.4. Default Barometric Pressure

The default barometric pressure is loaded into the live barometric pressure register when power is applied to the instrument or when the default barometric pressure is changed. The default barometric pressure is used in calculations until a live barometric pressure is written. The default barometric pressure value can be overridden by the OEM configuration file. This is not a measured parameter.

5.8.5. 100% Saturation Calibration Values

These values represent the conditions while the instrument is in a 100% saturation calibration environment. These are not measured values, they are written by the controller during the calibration process. Writes to these registers are only accepted if the instrument is in the calibration mode. The instrument will return exception 0x91 (invalid sensor command register sequence) if an attempt is made to write these registers when the calibration mode is off.

5.8.6. 0% Saturation Calibration Values

These values represent the conditions while the instrument is in a 0% saturation calibration environment. These are not measured values, they are written by the controller during the calibration process. Writes to these registers are only accepted if the instrument is in the calibration mode. The instrument will return exception 0x91 (invalid sensor command register sequence) if an attempt is made to write these registers when the calibration mode is off.

5.8.7. Calibration Slope and Offset

These values represent the slope and offset that will be applied to the raw concentration reading from the sensor to generate the final values reported by the sensor parameters. These registers may be written independent of the normal internal calibration procedure. Writes to these registers are only accepted if the instrument is in the calibration mode. The instrument will return exception 0x91 (invalid sensor command register sequence) if an attempt is made to write these registers when the calibration mode is off.

5.8.8. Calibration Status

This is a general-purpose register available to the controller to store additional information about the status of the calibration. Current usage is shown below.

0 = full stabilization achieved
1 = nominal stabilization achieved

This register may be written independent of the normal internal calibration procedure. Writes to this register are only accepted if the instrument is in the calibration mode. The instrument will return exception 0x91 (invalid sensor command register sequence) if an attempt is made to write the register when the calibration mode is off.

5.9. Percent Saturation Calibration Procedure

The RDO sensor is calibrated to percent saturation standards using the following procedure.

1. Write the Calibration Mode On command (0xE000) to the sensor command register.

2. Update the live salinity and barometric pressure registers if necessary.

3. Prompt the user to place the instrument in a 100% saturation environment.

4. Read the oxygen concentration and temperature parameters. When these values have reached equilibrium, record them in their respective 100% saturation calibration registers. Write the current live salinity and barometric pressure readings to their respective calibration registers.

5. Prompt the user to place the instrument in a 0% saturation environment. When these registers have reached equilibrium, record them in their respective 0% saturation calibration registers. If a zero calibration is not to be performed, these registers should be set to zero.

6. Set the calibration status register to reflect the status of the calibration.

7. Write the Calibration Update command (0xE001) to the sensor command register. The sensor will calculate a new slope and offset, write the current time to the last user calibration time register, set the next user calibration time register to zero (disabled), and record the calibration parameters. If the concentrations at 100% and 0% saturation are equal the sensor will return an exception response with code 0x97 (invalid calibration) and not attempt to compute a new slope and offset due to possible division by zero. If the slope does not calculate between 0.80 and 1.20 inclusive, or the offset does not calculate between -0.2 and +0.2 inclusive, the instrument will return an exception response with code 0x97 (invalid calibration). The slope and offset will be available to read but will not be committed to flash.

8. Optional: read the last user calibration time register, add the next calibration interval, and write the result to the next user calibration time register.

9. Write the Calibration Mode Off command (0xE002) to the sensor command register to place the sensor in normal operation. If the calibration mode is turned off without a calibration update command, or the calibration command returned an exception, the previous calibration will be restored.

5.9.1. Calibration Calculations

Calibrated Oxygen reading:

$$O_{2RC} = c_0 + c_1 \times O_{2RU}$$

where:

$$c_1 = \frac{O_2 100\,\%Sat}{O_{2RUS} - O_{2RUZ}}$$

$$c_0 = -c_1 \times O_{2RUZ}$$

$O_2 100\,\%Sat$ is the theoretical 100% saturation point.

O_{2RUS} is the un-calibrated reading at 100% saturation.

O_{2RUZ} is the un-calibrated reading at 0% saturation.

References:

Standard Methods:
4500-0 C. Azide Modification

5.10. Concentration Calibration Procedure

The RDO sensor is calibrated to concentration standards using the following procedure.

1. Write the Calibration Mode On command (0xE000) to the sensor command register.

2. Update the live salinity and barometric pressure registers if necessary.

3. Prompt the user to place the instrument in a concentration standard.

4. Read the oxygen concentration and temperature parameters. When these values have reached equilibrium record the results. Repeat steps 3 and 4 for each standard used.

5. Calculate a slope and offset correction for the data set and write the values to the slope and offset registers. If only one concentration standard is used, the slope should be set to 1 and the offset as (Standard – Reading). When either the slope or offset register is written, the instrument will set all percent saturation calibration values to zero.

   Note: The percent saturation calibration values should not be written in this calibration mode. Any non-zero value in the register set will cause the calibration update command to proceed as a percent saturation calibration.

6. Set the calibration status register to reflect the status of the calibration.

7. Write the Calibration Update command (0xE001) to the sensor command register. The sensor will record the new slope and offset, write the current time to the last user calibration time register, set the next user calibration time register to zero (disabled), and record the calibration parameters. If the slope is not between 0.80 and 1.20 inclusive, or the offset does is not between -0.2 and +0.2 inclusive, the instrument will return an exception response with code 0x97 (invalid calibration). The slope and offset will be available to read but will not be committed to flash.

8. Optional: read the last user calibration time register, add the next calibration interval, and write the result to the next user calibration time register.

9. Write the Calibration Mode Off command (0xE002) to the sensor command register to place the sensor in normal operation. If the calibration mode is turned off without a calibration update command, or the calibration command returned an exception, the previous calibration will be restored.

6. Modbus PLC Interface

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 parameter measurement registers are supported. Configuration and calibration registers are not accessible using this interface (the standard interface must be used instead).

6.1. Parameter Discovery

The first register read in a PLC measurement sequence should be a 14-register block read beginning with register number 6984. The bitwise contents of these registers indicate which parameter ids (1 to 219) are currently available from the instrument 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
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

6.2. 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, the parameter id for DO concentration is 20 (bit 3 will be set in register 6985). The starting register number for the DO concentration register block is thus (20 – 1) x 7 + 5451 = 5584.

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	Sentinel value

Continuing with the above example, to measure and read DO concentration, read the two-register floating point value at register 5584 (starting register 5584 + offset 0 = register 5584). To read the corresponding data quality id, read register 5586 (starting register 5584 + offset 2 = register 5586). Block reads within the parameter block are allowed. The DO concentration can be measured and read along with its data quality id by reading the 3 registers starting at register 5584, 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.

7. Probe Registers

Register	Size (registers)	Access Level (R/W)	Data Type	Description
47000	1	R1	ushort	Probe Register Map Template Version (1)
47001	1	R1	ushort	External Power Voltage (millivolts)