

# Reading Aquistar® Smart Sensors with Campbell Loggers

APPLICATION NOTE / SEPTEMBER 2010 / 9C0025r4

## Introduction

Instrumentation Northwest now offers an easy-to-read Modbus® version for several of their popular Aquistar® Smart Sensors. These sensors communicate via Modbus RTU and directly return measurement readings, without any further math on the part of the host system.

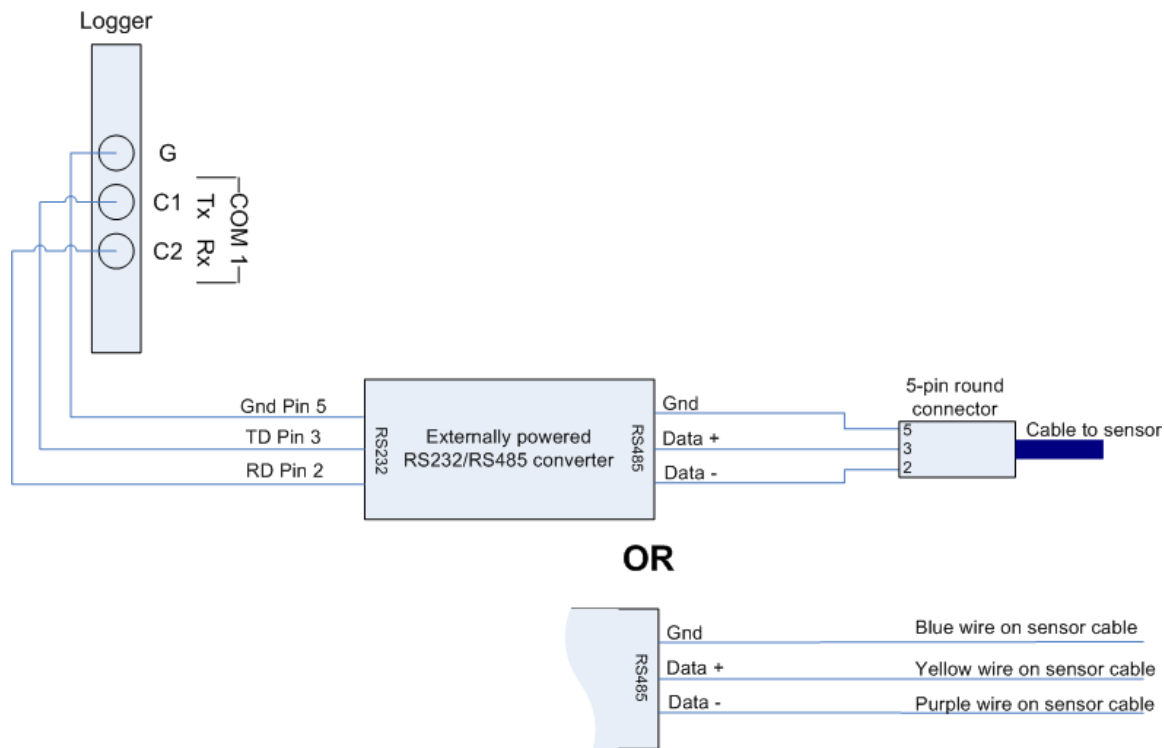
Currently, this feature is available on the PT2X Pressure/Temperature Sensor, the CT2X Conductivity/Temperature/Pressure Sensor, the T32 1Wire Temperature Logger, the GDL Datalogger, and the TempHion pH/ISE/Redox sensor.

The purpose of this document is to provide information on how to read INW's Aquistar® Smart Sensors with a Campbell datalogger via Modbus. Refer also to "Modbus Direct Read on Aquistar Smart Sensors" (Document # 9C0225) for information on available measurement units on the various sensors.

## Wiring

On a CR1000, sensors can be connected using either the Com1, Com2, Com3, or Com4 ports or the RS232 port. Some loggers do not have an RS232 port. On these loggers, you will have to use the Com1, Com2, etc. ports.

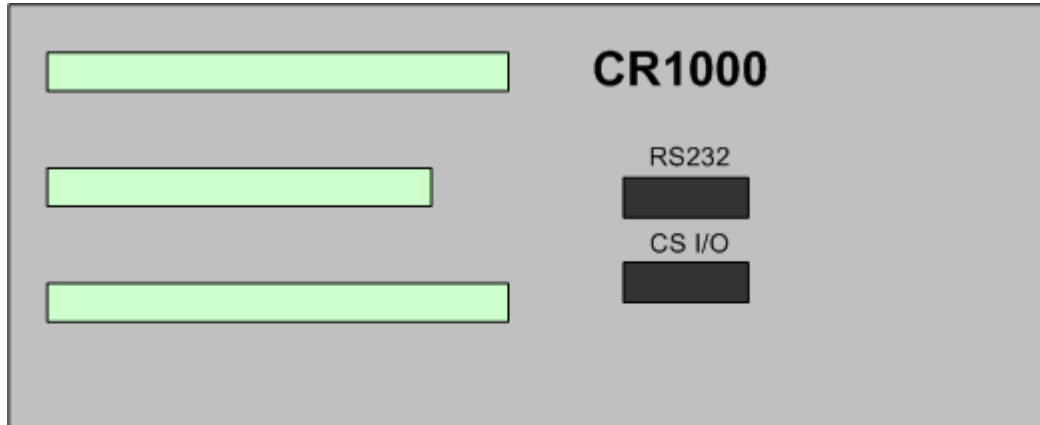
### Using the Com1, Com2, Com3, or Com4 Port



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## Using the RS232 Port on a CR1000



For communication with Loggernet:

CS I/O → 5C23B Adapter → PC Serial Port

For communication with CT2X:

RS232 → Null Modem Adapter → Port Powered RS232/RS485 Adapter →  
Communication Cable → Smart Sensor

## Taking Measurements

### Modbus Function

Measurements can be read using Modbus function 03 – Read Holding Registers.

### Data Format

The data is returned as a 32-bit IEEE floating-point value, high word first, also referred to as big-endian or float inverse.

### Reading Registers

You can read single values by reading the register set for the desired value. For example, to read only conductivity in a linear format from a CT2X, you would read two registers starting at 62595.

You can also read any contiguous sets of registers by starting at the register for the first value you want to read and specifying how many registers to read (two per channel). For example, to read all channels on a standard GDL, you would read 14 registers starting at 62593.

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## Register Addresses for PT2X, CT2X, TempHion, and T32

Sensor Type	PT2X	PT2X	CT2X	TempHion	T32
Firmware	1.5	>= 2.1	>= 1.5	>= 1.1	any

### Register

#### Address

Register Address	PT2X	PT2X	CT2X	TempHion	T32
62593	Pressure	Temperature	Temperature	Temperature	Temperature - 1
62595	Temperature	Pressure	Conductivity - Linear	mV-1 (in mV)	Temperature - 2
62597			Conductivity - non-Linear	mV-2 (in mV)	Temperature - 3
62599			Pressure	mV-3 (in mV)	Temperature - 4
62601				mV-1 (in pH, ppm, or Eh)	Temperature - 5
62603				mV-2 (in pH, ppm, or Eh)	Temperature - 6
62605				mV-3 (in pH, ppm, or Eh)	Temperature - 7
62607					Temperature - 8
62609					Temperature - 9
62611					Temperature - 10
62613					Temperature - 11
62615					Temperature - 12
62617					Temperature - 13
62619					Temperature - 14
62621					Temperature - 15
62623					Temperature - 16
62625					Temperature - 17
62627					Temperature - 18
62629					Temperature - 19
62631					Temperature - 20
62633					Temperature - 21
62635					Temperature - 22
62637					Temperature - 23
62639					Temperature - 24
62641					Temperature - 25
62643					Temperature - 26
62645					Temperature - 27
62647					Temperature - 28
62649					Temperature - 29
62651					Temperature - 30
62653					Temperature - 31
62655					Temperature - 32

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## Register Addresses for GDL

Sensor Type	GDL	GDL	GDL	GDL	GDL
Version	Standard	Dissolved Oxygen	Heart Rate Monitor	Rain Bucket	Generic Digital
Firmware	>= 2.5	>= 2.5	>= 2.5	>= 2.5	>= 2.5

### Register Address

62593	Temperature	Temperature	Temperature	Temperature	Temperature
62595	Temperature	Temperature	Temperature	Temperature	Temperature
62597	mV	mV	mV	mV	mV
62599	Voltage	Voltage	Voltage	Voltage	Voltage
62601	Voltage	Voltage	Voltage	Voltage	Voltage
62603	4-20 mA	4-20 mA	4-20 mA	4-20 mA	4-20 mA
62605	4-20 mA	4-20 mA	4-20 mA	4-20 mA	4-20 mA
62607		DO channel 1	Heart Rate	Rainfall	Custom Digital 1
62609		DO Temperature - 1			Custom Digital 2
62611		DO channel 2			Custom Digital 3
62613		DO Temperature - 2			Custom Digital 4
62615		DO channel 3			Custom Digital 5
62617		DO Temperature - 3			
62619		DO channel 4			
62621		DO Temperature - 4			

## Sample Code

The following pages contain sample code. The first sample reads a contiguous set of channels from a PT2X. To change this sample to work with your sensor, you will need to assign your sensor address, the starting register, number of channels to read, and the output column headers. The code is marked where you need to make the changes.

The second sample reads two individual channels (linear conductivity and pressure) from a CT2X. To change this sample to work with your sensor, you will need to assign your sensor address, the starting registers, the final value array size, the number of output columns, the output column headers, and the number of reading sets. The code is marked where you need to make the changes.

In both samples there is a subroutine called DecodeIEEEFloat. This code should not be changed. It is called after the reading has been taken to convert the two register readings into one 32-bit IEEE Float format number.

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## Direct Read Sample Code – Range of Channels

*'CR1000 Series Datalogger*

*'DirectRead\_sample\_range\_of\_channels.CRI*

*'Copyright Instrumentation Northwest, Inc. 2008 - 2010*

*'This program reads an INW Smart Sensor beginning with the first channel  
'and reading two channels in a row*

*'This particular version reads a PT2X with firmware 2.1 or higher  
'Temperature channel first and then the Pressure channel.*

*'\*\*\*\*\* Constants and Variables \*\*\*\*\**

Const SNSR\_ADDR = 3

*' Assign sensor address here!!!*

Const TAKE\_MEASUREMENT = 62593

*' Modbus address to begin readings*

Const NUM\_CHANNELS = 2

*' Number of channels to read*

Const NUM\_REGISTERS = NUM\_CHANNELS\*2

Assign your sensor address, the starting register, and number of channels to read here.

Public Result

Public sensor(NUM\_REGISTERS) As Long

*' Array to hold values read*

Public values(NUM\_CHANNELS)

*' Array to hold final values*

Public temperature As Float

*' Temperature*

Public pressure As Float

*' Pressure*

*'\*\*\*\*\* Define DataTables here, as desired \*\*\*\*\**

DataTable(Readings,True,-1)

Sample(1,values(1),IEEE4)

*' Column header for 1st channel*

FieldNames("Temperature")

Sample(1,values(2),IEEE4)

*' Column header for 2nd channel*

FieldNames("Pressure")

EndTable

Assign output column headers here.

*'\*\*\*\*\* Subroutine DecodeIEEEFloat \*\*\*\*\**

*' This subroutine takes two 16-bit registers and decodes them into*

*' a single IEEE 32-bit floating point value.*

*' This subroutine is called after taking Modbus readings to decode the data.*

*' You should not modify this subroutine, just use as is.*

Sub DecodeIEEEFloat (HW, LW, r)

*'\*\*\*\*\**

*'Take 32-bit value comprising two words, high word first,*

*'and convert to IEEE 754 32-bit floating point*

*'Bit 31: sign bit*

*'Bits 30 - 23: exponent*

*'Bits 22 - 0: mantissa*

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```
Dim man 'mantissa
Dim ex 'exponent
Dim sign 'sign
Dim a 'interim value
Dim b 'interim value
Dim c 'interim value
```

*'special case*

```
If HW = 0 AND LW = 0 Then
  r = 0
  Exit Sub
End If
```

*'Pull the 23 bit mantissa from the two separate words*  
man = LW + ((HW And ((2 ^ 7) - 1)) \* 2 ^ 16)

*'Get exponent*

```
a = 2 ^ 7
b = (2 ^ 8) - 1
```

```
ex = (Int(HW / a)) And b
```

*'Get sign*

```
'sign = Int(HW / (2 ^ 16)) And (2 ^ 1 - 1)
```

```
If HW < 0 Then
  sign = 1
Else
  sign = 0
End If
```

*'Compute final value*

```
c = 1 + man / (2 ^ 23)
r = ((-1) ^ sign) * c * (2 ^ (ex - 127))
```

```
End Sub
```

```
***** Begin Program *****
```

```
BeginProg
```

```
Dim i
```

```
*****
***** Scan Loop *****
```



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Scan (5,Sec,0,0)

```
'ModBusMaster ( ResultCode, ComPort, BaudRate, ModBusAddr, Function, Variable,
' Start, Length, Tries, TimeOut )
```

```
'wake up the sensor and wait 1 second for it to warm up
```

```
ModBusMaster (Result,ComRS232,38400,SNSR_ADDR,3,sensor(),TAKE_MEASUREMENT,NUM_REGISTERS,3,100)
```

```
Delay (0,1,sec)
```

```
'take a measurement
```

```
ModBusMaster (Result,ComRS232,38400,SNSR_ADDR,3,sensor(),TAKE_MEASUREMENT,NUM_REGISTERS,3,100)
```

```
' extract values, convert each set of two registers into one floating point value and put in values array
```

```
For i = 1 To NUM_REGISTERS step 2
```

```
DecodeIEEEFloat (sensor(i), sensor(i+1), values((i+1)/2))
```

```
Next i
```

```
CallTable Readings
```

```
NextScan
```

```
EndProg
```

## Direct Read Sample Results – Range of Channels

TIMESTAMP	RECORD	Temperature	Pressure
9/23/2010 14:33	1	24.5625	178.7823
9/23/2010 14:34	2	24.75	178.7813
9/23/2010 14:34	3	24.75	178.7803

## Direct Read Sample Code – Individual Channels

```
'CR1000 Series Datalogger
```

```
'DirectRead_sample_individual_channels.CR1
```

```
'Copyright Instrumentation Northwest, Inc. 2008 - 2010
```

```
'This program reads two individual channels from an INW Smart Sensor
```

```
'This particular version reads the Linear Conductivity value and the Pressure  
'from a CT2X with firmware 1.5 or higher
```

```
'***** Constants and Variables *****
```

```
Const SNSR_ADDR = 1
```

```
' Assign sensor address here!!!
```

```
Const TAKE_MEASUREMENT1 = 62595
```

```
' Modbus address for first reading  
'(in this case conductivity (linear))
```

Assign your sensor address and the starting register for each channel you want to read.

```
Const TAKE_MEASUREMENT2 = 62599
```

```
' Modbus address for second reading  
'(in this case pressure)
```

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////////////////////////////////////  
*'Add further Consts as are needed for the number of individual channels you want to read.*

```
Public Result
Public reading(2) As Long           ' Array to hold values read each time a channel is read
Public values(2) As Float          ' Array to hold final values, one value per channel
```

*\*\*\*\*\* Define DataTables here, as desired \*\*\*\*\**

```
DataTable(Readings,True,-1)
Sample(1,values(1),IEEE4)
FieldNames("Conductivity")      'Column header for 1st channel
Sample(1,values(2),IEEE4)
FieldNames("Pressure")          'Column header for 2nd channel
EndTable
```

Make the size of this array equal to the number of channels you want to read.

Assign output column headers here, adding Sample statements for each channel you want to read

```
***** Subroutine DecodeIEEEFloat *****
' This subroutine takes two 16-bit registers and decodes them into
' a single IEEE 32-bit floating point value.
' This subroutine is called after taking Modbus readings to decode the data.
' You should not modify this subroutine, just use as is.
```

```
Sub DecodeIEEEFloat (HW, LW, r)
*****
```

```
'Take 32-bit value comprising two words, high word first,
'and convert to IEEE 754 32-bit floating point
'Bit 31: sign bit
'Bits 30 - 23: exponent
'Bits 22 - 0: mantissa
```

```
Dim man 'mantissa
Dim ex 'exponent
Dim sign 'sign
Dim a 'interim value
Dim b 'interim value
Dim c 'interim value
```

```
'special case
If HW = 0 AND LW = 0 Then
    r = 0
    Exit Sub
End If
```

```
'Pull the 23 bit mantissa from the two separate words
man = LW + ((HW And ((2 ^ 7) - 1)) * 2 ^ 16)
```

```
'Get exponent
a = 2 ^ 7
b = (2 ^ 8) - 1
```

```
ex = (Int(HW / a) And b)
```





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```
////////////////////////////////////  
  
'Get sign  
'sign = Int(HW / (2 ^ 16)) And (2 ^ 1 - 1)  
If HW < 0 Then  
    sign = 1  
Else  
    sign = 0  
End If  
  
'Compute final value  
c = 1 + man / (2 ^ 23)  
r = ((-1) ^ sign) * c * (2 ^ (ex - 127))  
  
End Sub  
  
***** Begin Program *****  
BeginProg  
Dim i  
***** Scan Loop *****  
Scan (5,Sec,0,0)  
  
'ModBusMaster ( ResultCode, ComPort, BaudRate, ModBusAddr, Function, Variable,  
' Start, Length, Tries, TimeOut )  
  
'wake up the sensor and wait 1 second for it to warm up  
ModBusMaster (Result,ComRS232,38400,SNSR_ADDR,3,reading(),TAKE_MEASUREMENT1,2,3,100)  
Delay (0,1,sec)  
  
'Read first channel  
ModBusMaster (Result,ComRS232,38400,SNSR_ADDR,3,reading(),TAKE_MEASUREMENT1,2,3,100)  
' extract values, convert set of two registers into one floating point value and put in values array  
DecodeIEEEFloat (reading(1), reading(2)), values(1))  
  
'Read second channel  
ModBusMaster (Result,ComRS232,38400,SNSR_ADDR,3,reading(),TAKE_MEASUREMENT2,2,3,100)  
' extract values, convert set of two registers into one floating point value and put in values array  
DecodeIEEEFloat (reading(1), reading(2)), values(2))  
  
'Repeat for additional channels as needed  
  
CallTable Readings  
  
NextScan  
EndProg
```

Repeat the channel reading code for each channel you want to read, changing the register address and values array location, as needed.



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## Direct Read Sample Results – Individual Channels

TIMESTAMP	RECORD	Conductivity	Pressure
9/23/2010 15:05	0	5691.899	5.218782
9/23/2010 15:05	1	5691.899	5.218782
9/23/2010 15:05	2	5691.985	5.218782
9/23/2010 15:05	3	5692.812	5.218782

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