Adding a Site Offset to SDI12 Output

In some applications it is necessary to measure a site value including some reference data point, for example sea level. Assuming the sensor is installed 10m above sea level, then it is possible to have all reported readings add 10m, thus acquiring the data without the need for further modification. To add a site offset then:

1. Determine the offset to be applied.
2. Add the offset to the pressure units (e.g. aXU1,10!)
3. Save new calibration to nonvolatile memory (e.g. aXS0!)
4. Verify sensor now measures 10m for 0 applied pressure.

10. WARRANTY

The company warrants its products to be free from defects in material and workmanship in normal use and service for a period of two years from date of shipment. The Company reserves the right and option to repair or replaceupon evaluation of the returned original part. Modification, misuse, attempted repair by others, improper installation or operation shall render this guarantee null and void. The Company makes no warranty of merchantability or fitness for a part or purpose.

11. Servicing

The transducer cannot be repaired locally and if damaged should be returned to ourselves at the address shown below when a replacement/repair is required.

Setra Systems, Inc.
159 Swanson Road
Boxborough, MA 01719
Attn: Repair Department

12. Return to Factory

PLEASE NOTE: All returns must be accompanied with Setra's "Calibration and Service Order" return form. The form can be downloaded at:

http://www.setra.com/tra/repairs/pdf/webrepair.pdf

Any instrument returned without Setra's authorized form completely filled out will be quarantined and no action will occur. It may ultimately be returned to you and subject to a transportation charge.

159 Swanson Road, Boxborough, MA 01719/
Toll Free: 800-257-3872/ Phone: 978-263-1400/
Fax: 978-264-0292/Email: sales@setra.com/Web: www.setra.com

ISO 9001:2000 Certified

Model 595 Slimline Submersible Pressure Transducer

Setra Systems, Inc.

Contents

To re-range the 595 sensor proceed as follows:
1. Determine the 595 sensor full scale and the user application full scale.
2. Find the required calibration gain. Divide the 595 sensor full scale by the user application full scale (e.g. 10/4)
3. Program the calibration gain into the sensor (via SDI12 interface). (e.g. aXG2,2.5!)
4. Check the residual error with zero pressure applied. Note as the gain is increased any offset errors ban be magnified. So for example instead of 4mA expected sensor reads 3.959mA.
5. Program offset in calibration of sensor to remove offset errors (e.g. aXA2,0.041!)
6. Save new calibration to nonvolatile memory (e.g. aXS0!)
7 Verify sensor now measures 4 to 20mA for required application range.

Configure a Reverse Output 20mA to 4mA.
If your application demands a 20mA output with zero applied pressure and 4mA output for full scale applied pressure then the sensor output can be reversed by sending the following SDI12 commands:

1. Set calibration gain of mA output to -1 (e.g. aXG2,-1!)
2. Set calibration offset of mA output to +24 (e.g. aXZ2,24!)
3. Save new calibration to nonvolatile memory (e.g. aXS0!)
4. Verify sensor now measures 20mA to 4mA for 0 to full scale applied pressure.

Applying a Filter to the mA Output
In applications that are inherently difficult to measure, for example waves on reservoir, then the 595 can be configured to apply a mean or median filter via the SDI12 interface before updating the analogue mA output. The filter command is described below:

SDI12 Command: 0XFt,nn,xxxx!
Neptune Response: 0t,nn,xxxx<CR><LF>

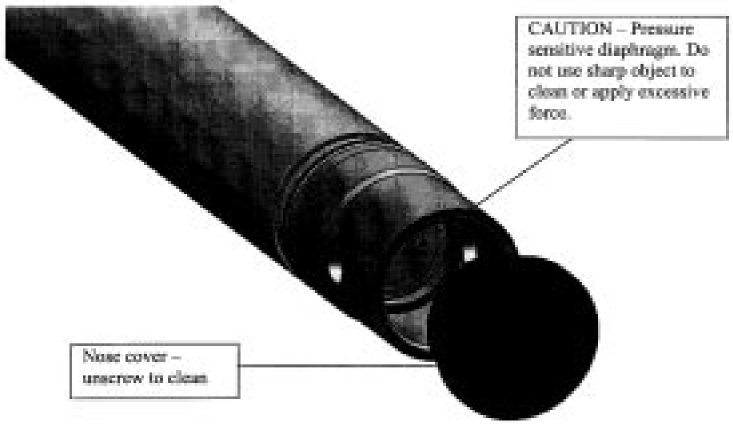
Where:
T = type of filter
0 = MEAN
1 = MEDIAN
nn = number of values to filter, maximum 12
xxxx = 220ms intervals between measurements, maximum period 1 hour

To apply a filter:
1. Determine the type of filter and period suitable for the application.
2. Send the filter command to the 595 sensor (e.g. 12 reading mean, sampling period 15 minutes, aXFt,12,4091A)
3. Save the filter to nonvolatile memory (e.g. aXS0!)
4. Verify the filter performance in applications.

8.3 Cleaning

Inspection and cleaning of the product is recommended as part of a preventative maintenance procedure. The required inspection period will depend on the nature of the application environment. To inspect the product unscrew the nose cover. Figure 2, and view the sensor diaphragm. The housing should be free from deposits. Cleaning with a cotton bud (Q-TIP) is possible, but extreme care must be taken not to deform the sensor diaphragm during cleaning.

Figure 2
Inspecting and Cleaning the Sensor



9. Advanced Operation

The 595 allows for a number of advanced operations not normally available.

Re-Range 4 to 20mA Output
Often users wish to measure a specific water level that is not the same as the full range output of the transducer. For example, if the sensor output was $10MH_2O$ and the user wishes to measure up to $4mH_2O$ then without a down range feature the output for the $10mH_2O$ unit in the users applications would be 0 to 40% of the range or 4 to 10.4mA. In this situation it is possible to use the SDI12 interface to program calibration coefficients into the sensor to provide 4 to 20 mA for the 0 to $4mH_2O$ application, with the $10mH_2O$ sensor.

1.0 Introduction

Model 595 is a level measuring transducer for precise measurements of ground and surface water levels. The transducer measures pressure and temperature signals and, by compensating these measured values for temperature effects, the relative density of water and the specific gravity in the users location, provide a highly accurate and repeatable "true" level measurement. The resultant level is available either as an analogue output or as a digital output

2.0 Safety Instructions

Important Note: Setra's Model 595 pressure transducer is designed and manufactured in accordance with Sound Engineering Practice as defined by the Pressure Equipment Directive 97/23/EC. Pressure transducer products designed to meet the highest risk category "IV" of the Pressure Equipment directive are clearly marked on the label by "CE0086". Compliance is achieved through modules "B&D". No other products should be used as "Safety Accessories" as defined by the PED, Article 1, Paragraph 2.1.3.

EMC: Model 595 conforms with the essential protection requirements of the EMC Directive 89/336/EEC amended by certified type testing to EN 61000-6-3 and EN61000-6-2. Conformity with the requirements of the CE mark only applies when the installation conditions described in these instructions have been met.

3.0 Hazardous Products

The 595 may be classified as Electrical, Electro-Mechanical and Electronic equipment.

These products are tested and supplied in accordance with our published specifications or individual special requirements that are agreed in writing at time of order. They are constructed so as not to affect adversely the safety of persons and property when properly installed, maintained and used by qualified personnel, in the applications for which they were designed and manufactured. Refer to installation and maintenance instructions for further details.

4.0 GENERAL

- Transducer should not be subjected to greater than maximum allowable pressure range as defined on the transducer label.
- Transducer should not be subjected to mechanical impact.
- The effects of decomposition of unstable fluids should be considered by the user when placing this device in service.
- Pressure range must be compatible with the maximum level being measured.
- Pressure media must be compatible with the transducer wetted parts which are:

  UNS31803 Stainless Steel, BS En 10088-3:1995 No. 1.4462.
  Polyurethane
  Acetal
  Nitrile

- Exposed end of cable must be kept free from moisture
- Liquid must not be allowed to freeze in the pressure port.

5.0 Action on Receipt

- Check accessories supplied include Calibration Certificate
- Check details on Calibration Certificate agree with data etched on transducer.

6.0 Installation

The 595 can be put to use in various applications, for example, in tubes or boreholes wider than one inch in diameter, in wells, open waters, and in non permanent water carrying riverbeds. The optional sink weight prevents the probe body from floating to the surface. The pressure probe can be easily fixated in flowing waters or waters with waves. When designing the measurement location, observe the hydrodynamic influence of strong currents (>0.5-1 m/s). Depending on the version and the type of mounting of the individual components, under pressure or over pressure may occur which may distort the measuring result.

Important: It is not recommended to install the pressure probe in the vicinity of docks, industrial waste water discharges or areas with high chemical pollution. The pressure probe is made of high-quality stainless steel and synthetic material. Nevertheless damaging corrosion may occur, depending on the installation location. For further information refer to the technical data of the wetted part materials.

6.1 Lowering the Pressure Probe

6.1.1 First determine the minimum and maximum water levels at the measuring point, for example, with a stuff gauge or contact gauge. Determine the probe position from these two values. The following prerequisites must be met:

* Position the probe below the minimal water level

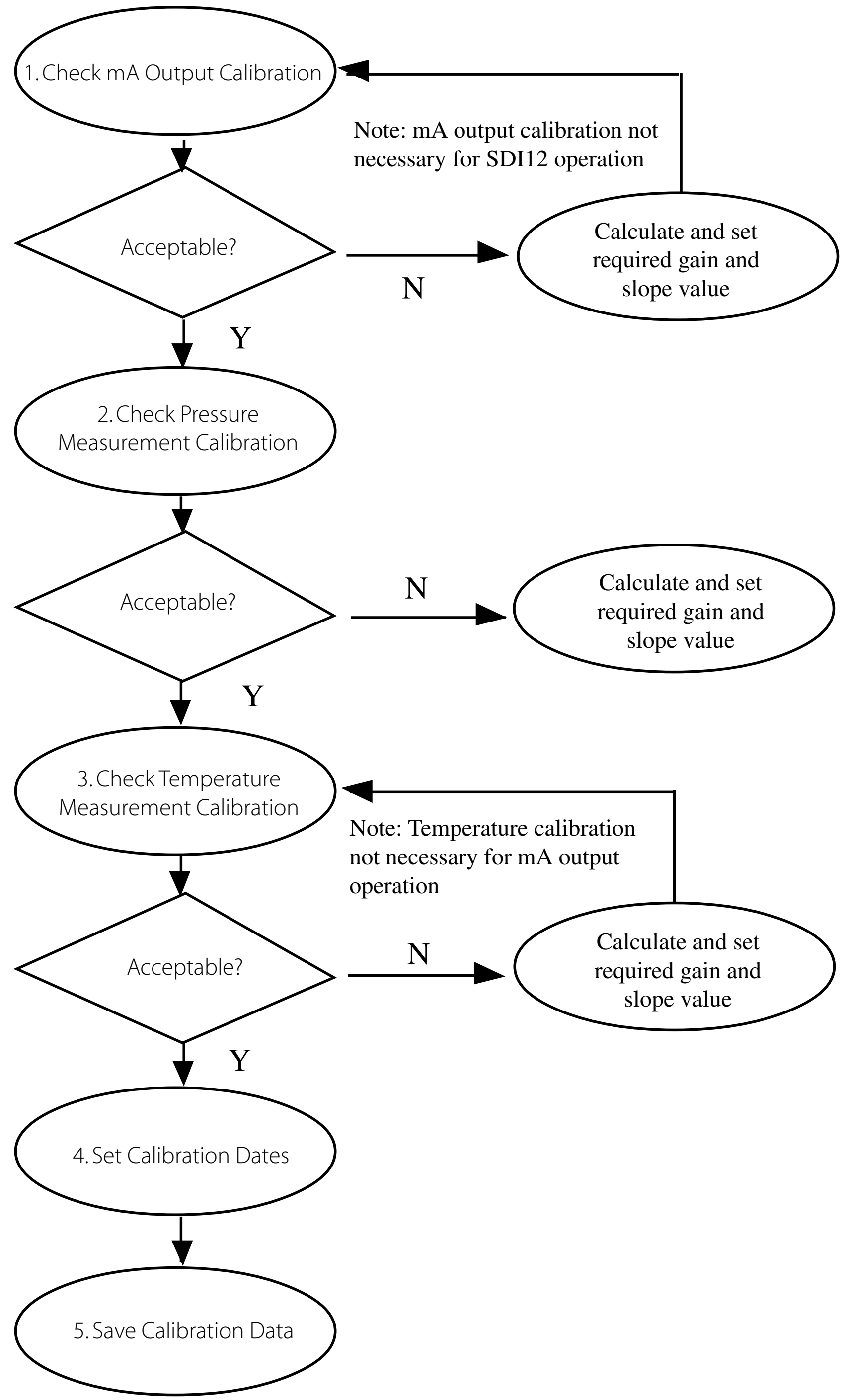
* Difference between maximum water level and probe position < measuring range of the probe.

6.1.2 Lower the pressure probe at the probe cable to the determined depth.

6.1.3 The cable should be suspended via a suitable cable suspension accessory. The integral Kevlar core provides mechanical strength within the cable, sufficient to suspend the probe.

6.1.4 Fine adjustment of the probe position may be performed via the probes digital interface. If the measured value is to be referenced to a zero level, this can be achieved by adding a user offset. Therefore, in most cases a coarse positioning of the probe is sufficient. In non permanently water-carrying riverbeds the pressure probe delivers a zero reading in a dry condition.

Figure 1
Recommended Calibration Procedure



Step 6: Apply Full Scale Value

Set Point Value 20 mA, actual reading 19.999 mA

Step 7: Calculate Errors and Record Results

Applied	Measured	Error
4.000	4.001	0.001
20.000	19.999	-0.001

Step 8 Write the Calibration Dates

Calibration dates are stored as nine character ASCII string. Assuming the calibration date was March 3rd 2005, then the dates could be written as shown in Table 14.

Table 14

Writing the Calibration Dates

Command	Response	Comment
aXL,03MAR2005!	a03MAR2005<CR><LF>	Writes the last calibration date.
aXN,03MAR2006!	a03MAR2006<CR><LF>	Writes the next calibration date.

Step 9 Save the Calibration

All data written remains nonvolatile until the save command is executed as shown in Table 15.

Command	Response	Comment
AXS0!	a0!	Saves all data

6.2 Electrical Installation

The 595 requires a D.C. power supply between 8V and 30V. The 595 includes suppression devices providing surge protection. In the event of a surge these devices can clamp across the power supply, providing protection against the surge. To avoid damage to the protection devices the power supply must be current limited so that the maximum normal operating current is 100mA. Where batteries are used directly this can easily be achieved via a series resistor, of suitable nominal value and power rating. For mA output units, the second consideration is the total resistance in the current loop. The maximum loop resistance is calculated by the formula:

Maximum Loop Resistance = (Vx - 8) * 50 ohms

Table 1 states the minimum and maximum resistance recommended.

Table 1

Recommended Power Supply Current Limit

Power Supply Voltage	Current Limit Limit	Series Resistance Note 1	Maximum Loop Resistance
12	0.1A	120 ohm	200 ohm
24	0.1A	240 ohm	800 ohm
30	0.1A	300 ohm	1100 ohm

Note 1.: Minimum series resistance only required where current limit of 0.1A is not provided by power supply.

The cable comprises 4 color-coded cores, with a central vent tube, enclosed by an aluminum/polyester screen where the screen is in intimate contact with a separate drain wire. The outer sheath can be of various material, depending upon application and operating temperature, standard suitable for most water environments is Polyurethane (immersed operating temperature -20°C to +50°C). Other cables are available on request for operation at higher temperatures or in more corrosive media. The cable should be terminated in a dry environment to avoid moisture entering the vent tube. If water enters this tube then erroneous measurements may result. In humid environments then it is recommended to terminate the cable into a suitable desiccator (see Setra's Model 299). The following electrical connections should be made:

Table 2

Connections mA Output Probes

Wire Color	Signal Name	Description
Red	VEx_+ve	Positive Excitation for the Probe
Blue	Vex_-ve	Negative Excitation for the Probe
None/Screen	Ground	Metalwork of Probe
Green*	SDI12	SDI12 Data

* Not required for 4 to 20 mA output operation

It is recommended to firmly secure the Kevlar core of the cable, for example, by knotting and securing under a fixing screw.

7.0 Operation

Having installed the transducer as instructed it is ready for use. Before applying power, check that the correct polarity and excitation levels are being applied. See Electrical Installation (6.2).

7.1 Analogue Output Probes

Analogue output devices will simply provide a 4 mA output for 0 level and a 20 mA output for the full scale level indicated on the product label. The analogue output can be adjusted via the digital SDI12 interface with a suitable accessory to include site offsets or provide full scale, 20 mA, output at a different level.

7.2 SDI12 Operation

The SDI12 interface conforms with the SDI12 V1.3 specification. Refer to the SDI12 host web-site for a full specification, http://www.sdi-12.org.

In addition to the standard SDI12 command set, the 595 supports a number of extended commands, providing increased levels of functionality. All sample commands provided are shown with address "a", to use the command substitute the actual address of the unit. The default address when manufactured is "0".

7.2.1 Setting up the Measured Variable

The transducer can provide either an output proportional to the applied pressure or a true level compensated for relative density of water. The preferred measured value must be set by the XP command as detailed in Table 3.

Table 3

Setting the Measured Variable

Command	Response	Comment
aXP0!	a0<CR><LF>	Set true level measure, compensated for relative density of water over temperature and local gravity.
aXP1!	a1<CR><LF>	Set pressure measure, no additional compensation.

7.2.2 Making a Level Measurement

The corrected level measurement is calculated in the following manner.

$$\text{Level} = mH_2O \text{ pressure at } 4℃ \quad * \quad \frac{1}{\text{density of water}} \quad * \quad \frac{9.80665}{\text{local gravity}}$$

where:

Density of water = $-6.017777e\text{-}6t^2 = 0.0000408t+0.999841$

where t - temperature in ℃.

Table 12
Calibration of the mA Output

Command	Response	Comment
aXM4	a4.00000<CR><LF>	Sets the mA output to 4 mA. Measure the current and record the actual value.
aXM20	a20.0000<CR><LF>	Sets the mA output to 20.0 mA. Measure the current and record the actual value.

Step 1: **Apply Zero Scale Value**
Set Point Value 4mA, actual reading 4.005 mA.

Step 2: **Apply Full Scale Value**
Set Point Value 20mA, actual reading 19.995 mA.

Step 3: **Calculate the Errors and Adjustment Values**
The value to write to the offset calibration adjustment is calculated by subtracting the measured value of 4mA from the 4mA set point as shown:
Set point zero = 4.000
Measured zero = 4.005
Offset Value = 4.000-4.005 = -0.005 mA

Step 4: **Write the Calibration Adjustment Values**
The value to write to the gain calibration adjustment is calculated by dividing the set point span by the measure span as shown:
Set point span = (20-4) = 16 mA
Measured span = (19.995-4.005) = 15.99 mA
Gain value = 16/15.99 = 1.0006254

Table 13 shows the command required to write the calibration adjustment to the 595:

Table 13
Writing the mA Output Calibration

Command	Response	Comment
AXZ3,-0.005!	a-0.00500<CR><LF>	Writes the offset of -5µA to the mA output zero.
AXG3,1.0006254!	A1.006254<CR><LF>	Writes the gain value t the mA output.

Step 5: **Apply Zero Scale Value**
Set Point Value 4mA, actual reading 4.001mA.

8.2 Calibration Adjustment

The 595 is designed to provide excellent long-term stability, however, occasionally it is necessary to verify the calibration and perform adjustment. Setra offers an annual recalibration service, via return to the service department. Alternatively a two point calibration adjustment of each variable provided by the 595 is possible via the SDI12 interface. This is achieved through three independent adjustments i.e. pressure, temperature and mA output. The recommended calibration procedure is detailed in Figure 1. Writing of calibration adjustment values is performed via the aXZ and aXG commands. These commands have the following syntax:

aXZn,<value>
aXGn,<value>
where: n = channel to be calibrated
<value> = value of calibration coefficient

Three calibration channels are supported:

n = 0 = Pressure
n = 1 = Temperature
n = 2 = mA Output (response to pressure signal)
n = 3 = mA Output (fixed output)

Calibration of any channel is basically the same and consists of 9 simple steps:

1. Apply zero scale value and record the measured value.
2. Apply full scale value and record the measured value.
3. Calculate the errors and adjustment values (if required.)
4. Write the calibration adjustment values to the 595.
5. Apply zero scale values and record the measured value.
6 Apply full scale value and record the measured value.
7. Calculate new errors and record results.
8. Write the last and next calibration dates.
9. Save the calibration.

8.2.1 Example of mA Output Calibration

The mA Output consists of two discrete components:
1. The analogue to digital conversion of the measured pressure and temperature values.
2. The digital to analogue conversion, providing the analogue output.

Step 1 in Figure 1 refers to checking the calibration of the digital to analogue conversion of the mA output. For SDI12 output, this step is not necessary. The calibration of mA output stage can be verified using an extended command to set a fixed mA output value as shown in Table 12

The temperature is a measured value and thus the density of water at any given time is calculated by the transducer. The user may enter a local gravity value via the XE command as detailed in Table 4

Table 4

Entering the Local Gravity

Command	Response	Comment
aXE9.81!	a9.81<CR><LF>	Sets the local gravity value to 9.81 m/s^2

7.2.3 Selecting a Commonly Used Unit of Measurement

For SDI12 output units it is possible to change the units of the measured variables, pressure and temperature. The extended commands aXUTn! and aXUPn! are used to change the temperature and pressure units respectively. Note the value of n specifies the required unit as shown in Tables 5 and 6.

Table 5

Selecting Temperature Units

Command	Response	Comment
aXUT0!	a0<CR><LF>	Sets the temperature units to ℃
aXUT1!	a1<CR><LF>	Sets the temperature units to ℉
aXUT!	a1<CR><LR>	Queries the temperature unit without setting a value

Table 6

Selecting Pressure Units

Command	Response	Comment
aXUP0!	a0<CR><LF>	Sets the pressure units to mH_2O
aXUP1!	a1<CR><LF>	Sets the pressure units to ftH_2O
aXUP2!	a2<CR><LF>	Sets the pressure units to inH_2O
aXUP3!	a3<CR><LF>	Sets the pressure units to bar
aXUP4!	a4<CR><LF>	Sets the pressure units to psi
aXUP!	a4<CR><LF>	Queries the pressure unit without setting a value

Note: The pressure units (bar, psi) are not valid when configured for a true level output

7.2.4 Setting Up a Custom Unit Scaling

Unit conversion performed by the 595 is of the form y=mx+c. Where units other than the commonly used set provided are required then the m and c can be written directly. This is achieved via the command aXUn, <value>!. Note n represents the variable to be written with the following value as detailed in Table 7.

Table 7

Variables Used for Unit Conversions

Value of n	Variable Written
0	Pressure Units Slope = m
1	Pressure Units Offset = c
2	Temperature Units Slope = m
3	Temperature Units Offset = c

The value of m should be calculated as follows:

For Pressure: m = (Full Scale in User Units – Zero Scale in User Units)
(Full scale in mH_2O at 4℃ – Zero Scale in mH2O at 4℃)

For Temperature: m = (Full Scale in User Units - Zero Scale in User Units)
(Full Scale in ℃ – Zero Scale in ℃)

The appropriate values can then be written as show in Tables 8 and 9.

Table 8

Setting the Pressure Units to mbar

Command	Response	Comment
aXU0,98.0665!	a0<CR><LF>	Sets the slope m to 98.0665, equivalent to mbar.
aXU1,0!	a1<CR><LF>	Sets the offset to 0 as 0 mbar = $0mH_2O$ at 4℃

Table 9

Setting Temperature Units to Kelvin

Command	Response	Comment
aXU2,1!	a1<CR><LF>	Sets the slope m as same as ℃
aXU3,-273!	a1<CR><LF>	Sets the offset to -273 to read in Kelvin

7.2.5 Obtaining Maximum and Minimum Measurements

The 595 supports the following additional measurements via the measure and concurrent measurement commands.

aM1! = Maximum Level / Pressure
aM2! = Minimum level / Pressure
aM3! = Maximum Temperature
aM4! = Minimum Temperature

The maximum and minimum values should be reset using the XMM command as shown in Table 10.

Table 10
Resetting Maximums and Minimums

Command	Response	Comment
aXMM1!	a1!	Resets the maximum level to the current value
aXMM2!	a2!	Resets the minimum level to the current value
aXMM3!	a3!	Resets the maximum temperature to the current value
aXMM4!	a4!	Resets the minimum temperature to the current value

8. Maintenance

8.1 Self diagnostics

The 595 performs a significant amount of self-diagnostics upon reception of the verify command, aV!. It is recommended that any system design should include a periodic execution of the verify command. The response to a verification command includes an error code. Table 11 summarizes the possible error codes from the verification command.

Table 11

	Diagnostics
Error Code	Description
0	No Error, unit is functioning normally
1	The temperature measurement is beyond the calibrated range
2	The pressure measurement is beyond the calibrated range
4	The nonvolatile memory has been incorrectly accessed
8	An analogue signal error exists
16	Reserved
32	The nonvolatile user data is in error
64	The nonvolatile calibration data is in error
128	RAM error
256	Watchdog error

Note: If an error code >3 is returned, record the value and contact the manufacturer