8-Channel SDI-12 Analog Input Module

Model
H-4280

Owner's Manual
Version 2.0
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This Agreement and its validity and interpretation shall be governed by the laws of the State of Utah, notwithstanding any choice of law rules of Utah or any other state or jurisdiction.
Chapter 1
Introduction

1.0 Introduction
The WaterLOG® Model H-4280 is a 24-bit, 8-channel, analog input module. The module is an intelligent SDI-12 “sensor” and can provide measurement data in engineering units such as feet or meters.

The H-4280 is easy to use and works with any data recorder//logger with a SDI-12 interface. The module is powered from the +12V wire of the 3-wire SDI-12 bus. The SDI-12 (Serial Digital Interface 1200–baud) is ideal for data logging applications with the following requirements:

- Battery powered operation with minimal current drain
- Measurement data is transmitted digitally over long cable lengths without error
- Multiple sensors on a simple three-wire cable
- Up to 250 feet of cable between a sensor and the data recorder (Use of a H-423, SDI-12 to RS485 or H-4500 fiberoptic media converter extends the range to 1000's of feet)

The H-4280 has the following features:

- Works with any SDI-12 compliant data logger
- 8-analog input channels
- Supports unipolar (0-5V), bipolar (±5V) and differential (0-5V & ±5V) operation. (Inputs must remain between 0 and +5V)
- 24-bit A/D makes up to 12 measurements per second
- Precision 5.0V reference output for sensor excitation
- Sensor warmup time (excitation) is programmable
- Low power sleep operation (<400µA)
- Programmable data averaging
- Programmable slope, offset and format settings for each of the 8-channels
- Built in extended SDI-12 commands for setup and configuration.
- Plug-in terminal connectors

1.1 Description
The H-4280 is primarily used to interface simple analog sensors to a SDI-12 compliant data logger. Many sensors such as potentiometers, thermistors, and pressure sensors can be connected directly to the H-4280. Each channel can be configured with a y=mX+b linear equation to convert the input voltage into user units such as temperature, pressure, feet or meters. The linear equation has a slope (m) term and an offset (b) term. At the factory the slope is set to 1.0 and the offset to 0.00, with these values the measurement will be in units of Volts. The linear equation will work for sensors such as potentiometers, shaft encoders and 4-20mA transducers with linear outputs. The y=mX+b equation will not work with thermocouples, thermistors and other sensors having a non-linear response. For these sensors, leave the slope = 1.0, offset = 0.0 and perform the more complex math operations in your data logger.

1.2 Input Settings
When the data logger issues an aM! command to initiate a measurement, the H-4280 makes 8-measurements, one for each channel. Each channel can be configured to make Unipolar/Bipolar and
Single/Differential measurements. The results of the 8-measurements are placed in the sensor buffer and can be collected with aD0! and aD1! commands.

<table>
<thead>
<tr>
<th>Type</th>
<th>Range</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unipolar</td>
<td>0 to 5.0 Volts</td>
<td>0.3uV</td>
</tr>
<tr>
<td>Bipolar</td>
<td>±5.0 Volts</td>
<td>0.6uV</td>
</tr>
<tr>
<td>Single Ended</td>
<td>Measurement is referenced to ground</td>
<td></td>
</tr>
<tr>
<td>Differential</td>
<td>Measures the difference between two adjacent input channels (0-1, 2-3, 4-5, 6-7)</td>
<td></td>
</tr>
</tbody>
</table>

The H-4280 always makes 8-measurements, even if one or more of the channels is configured for a differential measurement. For example; if Channel 0 is configured for a differential measurement, the Channel 0 measurement is determined by the input voltage on both Channel 0 & 1. Subsequently a measurement is made for Channel 1, with the results determined separately by the settings of Channel 1. Normally if Channel 0 is configured for a differential measurement, the results of the adjacent channel measurement (Channel 1) is ignored by the data logger (and vice versa).

1.3 Single-Ended Analog Inputs
A single-ended analog measurement is one which is referenced to ground. The H-4280 can make up to eight single-ended measurements. Both unipolar and bipolar measurements can be selected. The 12-position input connector has 3-terminals for making ground connections. Unused inputs may be left floating, however the measurement data from unused inputs channels is undefined and will drift.

1.4 Differential Analog Inputs
A differential analog measurement is one which measures the difference between two input terminals. The two terminals have positive and negative input response respectively. The H-4280 can make up to 4 differential measurements. Both unipolar and bipolar measurements can be selected. If the (+) input will always more positive than the (-) input, set the channel to “unipolar”. The unipolar setting has the best resolution. If the (+) can be less positive than the (-) input, set the channel to “bipolar”. The bipolar setting allows the measurement to go negative but has the shortcoming of 1-bit less resolution.

1.5 Excitation Output
The H-4280 has a precision 5.00V excitation output terminal for powering potentiometers, thermistors and other sensors. The +5Vref terminal is internally connected to the A/D converter. Measurements made with resistance sensors powered from the +5Vref terminal will be “ratiometric” in that errors in the absolute value of the reference cancel out. The +5Vref output is normally turned off to save power while the module is in its sleep mode and is switched on before a measurement is made. The “warmup time” is a programmable delay (0 to 999 seconds) which elapses before the first measurement is made. If desired, the excitation output can be programmed to remain active while the module is asleep. The +5Vref terminal is for powering potentiometers, thermistors and other low current sensors. Do not draw more than 50mA from the +5Vref terminal.

1.6 Sensors With Current Output
The H-4280 measures input voltage. Sensors which output current can be connected to the H-4280 with the aid of a shunt resistor. For example, a 4-20mA sensor can be interfaced by connecting a precision 250 ohm shunt resistor between the input and a ground terminal. When the sensor is transmitting its 20mA maximum output the H-4280 will input 5.0Volts: (5.0V = .020mA x 250 Ohms).

1.7 Averaging
The H-4280 can make up to 80 measurements/second (per 8-channels). The module makes multiple measurements, averages the results (simple mean) and reports one measurement per channel. The number of samples can be programmed from 1 to 255, the H-4280 comes from the factory configured to make 10
samples for each channel. The number of samples per measurement (1-255) is the same for all 8-channels.
2.1 Installing The H-4280

The WaterLOG® H-4280 is an 8-channel analog to digital SDI-12 “sensor”. Many sensors such as potentiometers, thermistors, and pressure sensors can be connected directly to the H-4280.

2.2 General Installation Recommendations

The H-4280 housing and connectors are not weather tight. The H-4280 must be installed in a protected location or a weather tight enclosure. The housing has a 4-terminal connector for making power and SDI-12 connections and a 2-segment, 12-terminal connector for connecting the analog inputs. The connectors can be detached while making the connections.

Caution: Remove all power from the unit before making any connections.

Before beginning the installation take a minute to plan out your station grounding and wiring scheme. Use a single point ground system design to avoid having high current (power) flowing into or out of the ground terminals of the analog input connector. If your sensors have separate signal and power connections, connect only the signal and its ground reference to the input connector. Use shielded cables where possible. Use a shielded, twisted-pair cable when making connections to a differential input. Install lightening and other transient voltage protection if the sensors and wiring are exposed to damage. Power the sensors from the same battery or power supply which supplies the data logger, this makes certain input voltages to the H-4280 are not present if the H-4280 is powered off.
2.3  +5Vref Output
The H-4280 has a precision 5.00V excitation output terminal for powering potentiometers, thermistors and other sensors. The +5Vref terminal is internally connected to the A/D converter. Measurements made with resistance sensors powered from the +5Vref terminal will be “ratiometric” in that errors in the absolute value of the reference cancel out. The +5Vref output is normally turned off to save power while the module is in its sleep mode and is switched on before a measurement is made. The “warmup time” is a programmable delay (1 to 999 seconds) which elapses before the first measurement is made. If desired, the excitation output can be programmed to remain active while the module is asleep. The +5Vref terminal is for powering potentiometers, thermistors and other low current sensors. Do not draw more than 50mA from the +5Vref terminal.

The warmup delay is configured with the extended “aXRWT!” and “aXWWTnnn!” commands. The +5Vref power mode during sleep is configured with the extended “aXRPM!” and “aXWPMnnn!” commands. See Chapter 3 for details.

2.4  Averaging
The H-4280 can make up to 80 measurements/second (per 8-channels) The module makes multiple measurements, averages the results and reports one measurement per channel. The number of samples can be programmed from 1 to 255, the H-4280 comes from the factory configured to make 10 samples for each channel. The number of samples per measurement (1-255) is the same for all 8-channels. This setting is configured with the extended “aXRMC!” and “aXWMCnnn!” commands. See Chapter 3 for details.

2.5  Channel Settings
Each channel can be configured to make Unipolar/Bipolar and Single/Differential measurements.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unipolar</td>
<td>0 to 5.0 Volts - resolution is 0.3uV</td>
</tr>
<tr>
<td>Bipolar</td>
<td>±5.0 Volts - resolution is 0.6uV (Inputs must remain between 0 and +5V)</td>
</tr>
<tr>
<td>Single Ended</td>
<td>Measurement is referenced to ground</td>
</tr>
<tr>
<td>Differential</td>
<td>Measures the difference between two adjacent input channels (0-1, 2-3, 4-5, 6-7)</td>
</tr>
</tbody>
</table>

These and other settings are configured with the extended “aXRCn!” and “aXWCMn!” commands. See Chapter 3 for details.
2.6 Slope & Offset
Each channel can be configured with a y=mX+b linear equation to convert the input voltage into user units such as pressure, feet or meters. The linear equation has a slope (m) term and an offset (b) term. At the factory the slope is set to 1.00 and the offset to 0.00, with these settings the measurement will be in units of Volts. The linear equation will work for sensors such as potentiometers, position sensors and 4-20mA transducers with linear outputs. The y=mX+b equation will not work with thermocouples, thermistors and other sensors having a non-linear response. For these sensors, leave the slope = 1.0, offset = 0.0 and perform the more complex math operations in your data logger. The slope and offset settings are configured with the extended “aXROn!” & “aXWO n!” “aXRSn!” & “aXWSn nn!” or the “aXRCn!” & “aXWCn!” commands. See Chapter 3 for details.

2.7 Data Format
The number of digits printed past the decimal point can be configured for each channel. For example if Digits = 2 for a particular channel the respective data will have two digits beyond the decimal point (x.xx). At the factory all 8-channels are set for 3-digits beyond the decimal point. These settings are configured with the extended “aXRCn!” & “aXWCn!” commands. See Chapter 3 for details.

2.8 Programming Your SDI-12 Data Recorder
You must prepare your data recorder to receive and record the H-4280 data. Since data recorders differ, refer to your data recorder manufacturer's directions. In general, program the data recorder to input 8-values via the SDI-12 port. All eight parameters do not need to be actually recorded. Your data recorder must issue an “aM!” command, then collect the data with “aD0!” and “aD1!” commands, as explained in Chapter 3. Four parameters are returned in response to the “aD0!” command and four more with the “aD1!” command.

The H-4280 places eight parameters in its data buffer:

```
a+A.AAA+BB.BBB+C.CCC+D.DDD<CR><LF>
a+E.EEE+F.FFF+G.GGG+H.HHH<CR><LF>
```

Where:

- `a` = SDI-12 address 0-9, A-Z
- A.AAA = Channel 0
- B.BBB = Channel 1
- C.CCC = Channel 2
- D.DDD = Channel 3
- E.EEE = Channel 4
- F.FFF = Channel 5
- G.GGG = Channel 6
- H.HHH = Channel 7
2.9 Testing
For preliminary testing a simple potentiometer can be used to simulate one or more sensors. Connect one end of the potentiometer resistor to a ground terminal and the other end to the +5Vref terminal. Connect the potentiometer wiper to one of the input channels. Make several measurements while adjusting the potentiometer and check for the expected results.

2.10 “XTEST”
The “XTEST” command is used for installation or production testing and requires the use of a H-4191 Sidekick interface and a PC. This command causes the H-4280 to transmit unsolicited real-time data for testing purposes. The test mode is used to help troubleshoot the installation by providing a continuous readout of measurement data. This is not compliant with the SDI-12 specification and is not used with data loggers.

To activate the test mode, send the command “aXTEST!” from the PC. The H-4280 will enter the test mode and make and print continuous measurements. The test mode is exited by sending a break or any new command on the SDI-12 bus. For example:

```
0: +1.202 +3.222 +1.234 +2.345 +2.677 +3.333 +1.202 +1.202
0: +1.202 +3.222 +1.234 +2.345 +2.677 +3.333 +1.202 +1.202
0: +1.202 +3.222 +1.234 +2.345 +2.677 +3.333 +1.202 +1.202
0: +1.202 +3.222 +1.234 +2.345 +2.677 +3.333 +1.202 +1.202
```
3.0 SDI-12 Command and Response Protocol

This is a description of the Serial Digital Interface (SDI-12) Command and Response Protocol used by the WATERLOG* Series Model H-4280 sensor. Included is a description of the commands and data format supported by the H-4280.

Refer to the document "A SERIAL DIGITAL INTERFACE STANDARD FOR HYDROLOGIC AND ENVIRONMENTAL SENSORS". Version 1.3 January 12, 2009 Coordinated by the SDI-12 Support Group, 135 East Center, Logan, Utah.

During normal communication, the data recorder sends an address together with a command to the H-4280 SDI-12 sensor. The H-4280 then replies with a "response." In the following descriptions, SDI-12 commands and responses are enclosed in quotes. The SDI-12 address and the command/response terminators are defined as follows:

"a" Is the sensor address. The following ASCII Characters are valid addresses: "0-9", "A-Z", "a-z", "*", "?". Sensors will be initially programmed at the factory with the address of "0" for use in single sensor systems. Addresses "1 to 9" and "A to Z" or "a to z" can be used for additional sensors connected to the same SDI-12 bus. Address "*" and "?" are "wild card" addresses which select any sensor, regardless of its actual address.

"!" Is the last character of a command block.

"<cr><lf>" Are carriage return (0D) hex and line feed (0A) hex characters. They are the last two characters of a response block.

Notes:

- All commands/responses are upper-case printable ASCII characters.
- Commands must be terminated with a "!" character.
- Responses are terminated with <cr><lf> characters.
- The command string must be transmitted in a contiguous block with no gaps of more than 1.66 milliseconds between characters.

To enhance the error detection capability in SDI-12 data collection systems, a variation of the Start Measurement Commands (M!, M1! ... M9!), Start Concurrent Measurement Commands (C!, C1! ... C9!), and Continuous Measurement Commands (aR0! ... aR9!) request that the data be returned with a 16 bit Cyclic Redundancy Check (CRC) appended to it. These commands use the existing command letters with a C appended, namely: aMC!, aMC1! ... aMC9!, aCC!, aCC1! ... aCC9!, and aRC0! ... aRC9!. When these commands are used, the data returned in response to the D commands, or R commands, have a CRC code appended to it.
3.1 Master SDI-12 Command List

Standard SDI-12 commands

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>aM!</td>
<td>Make Measurement</td>
</tr>
<tr>
<td>aMC!</td>
<td>Make Measurement with CRC</td>
</tr>
<tr>
<td>aC!</td>
<td>Make Concurrent Measurement</td>
</tr>
<tr>
<td>aCC!</td>
<td>Make Concurrent Measurement with CRC</td>
</tr>
<tr>
<td>aD0! and aD1!</td>
<td>Send Data</td>
</tr>
<tr>
<td>aV!</td>
<td>Verify Sensor</td>
</tr>
<tr>
<td>aI!</td>
<td>Send Identification</td>
</tr>
</tbody>
</table>

Extended SDI-12 commands unique to the H-4280

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>aAn!</td>
<td>Change sensor address</td>
</tr>
<tr>
<td>aXRCn!</td>
<td>Read configuration of channel n</td>
</tr>
<tr>
<td>aXWCn!</td>
<td>Write configuration of channel n</td>
</tr>
<tr>
<td>aXSCSn ddd!</td>
<td>Set current “stage” of channel n</td>
</tr>
<tr>
<td>aXRSn!</td>
<td>Read Slope of channel n</td>
</tr>
<tr>
<td>aXWSn ddd!</td>
<td>Write Slope of channel n</td>
</tr>
<tr>
<td>aXROn!</td>
<td>Read Offset of channel n</td>
</tr>
<tr>
<td>aXWOn ddd!</td>
<td>Write Offset of channel n</td>
</tr>
<tr>
<td>aXRMC!</td>
<td>Read Mean_Count</td>
</tr>
<tr>
<td>aXWMCnnn!</td>
<td>Write Mean_Count</td>
</tr>
<tr>
<td>aXRPM!</td>
<td>Read Power_Mode</td>
</tr>
<tr>
<td>aXWPMn!</td>
<td>Write Power_Mode</td>
</tr>
<tr>
<td>aXRWT!</td>
<td>Read Warmup_Time</td>
</tr>
<tr>
<td>aXWWTnnn!</td>
<td>Write Warmup_Time</td>
</tr>
<tr>
<td>aXTEST!</td>
<td>Initiate a repeating test printout</td>
</tr>
</tbody>
</table>
3.2 Measure Command
The Measure Command causes a measurement sequence to be performed. Data values generated in response to this command are stored in the sensor's buffer for subsequent collection using "D" commands. The data will be retained in the sensor until another "M", "C", or "V" command is executed.

Command | Response | Description
---|---|---
"aM!" | "atttn<cr><lf>" | Initiate measurement

Where:
- a is the sensor address ("0-9", "A-Z", "a-z", ",", ",")
- M is an upper-case ASCII character
- ttt is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have measurement data available in its buffer.
- n is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "D" commands.

Upon completion of the measurement, a service request "a<cr><lf>" is sent to the data recorder indicating the sensor data is ready. The data recorder may wake the sensor with a break and collect the data any time after the service request is received or the specified processing time has elapsed.

Example of a H-4280 "aM!" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aM!&quot;</td>
<td>&quot;a0038&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>3 sec</td>
<td>8</td>
<td>Make measurement</td>
</tr>
</tbody>
</table>

Subsequent Command | Response
---|---
"aD0" | a+A.AAA+B.BBB+C.CCC+D.DDD<CR><LF>
"aD1" | a+E.EEE+F.FFF+G.GGG+H.HHH<CR><LF>

Where:
- A.AAA = Channel 0 Voltage
- B.BBB = Channel 1 Voltage
- C.CCC = Channel 2 Voltage
- D.DDD = Channel 3 Voltage
- E.EEE = Channel 4 Voltage
- F.FFF = Channel 5 Voltage
- G.GGG = Channel 6 Voltage
- H.HHH = Channel 7 Voltage
3.3 Measure with CRC Command

The Measure Command causes a measurement sequence to be performed with a CRC appended to the data. Data values generated in response to this command are stored in the sensor's buffer for subsequent collection using "D" commands. The data will be retained in the sensor until another "M", "C", or "V" command is executed.

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aM!&quot;</td>
<td>&quot;atttn&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>Initiate measurement</td>
</tr>
</tbody>
</table>

Where:

- **a** is the sensor address ("0-9", "A-Z", "a-z", ",", ",?").
- **M** is an upper-case ASCII character
- **ttt** is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have measurement data available in its buffer.
- **n** is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "D" commands.

Upon completion of the measurement, a service request "a<cr><lf>" is sent to the data recorder indicating the sensor data is ready. The data recorder may wake the sensor with a break and collect the data any time after the service request is received or the specified processing time has elapsed.

**Example of a H-4280 "aMC!" command:**

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aMC!&quot;</td>
<td>&quot;a0038&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>3 sec</td>
<td>8</td>
<td>Make measurement</td>
</tr>
</tbody>
</table>

**Subsequent Command**

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aD0&quot;</td>
<td>a+A.AAA+B.BBB+C.CCC+D.DDDDXXX&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>&quot;aD1&quot;</td>
<td>a+E.EEE+F.FFF+G.GGG+H.HHHXXX&lt;CR&gt;&lt;LF&gt;</td>
</tr>
</tbody>
</table>

Where:

- A.AAA = Channel 0 Voltage
- B.BBB = Channel 1 Voltage
- C.CCC = Channel 2 Voltage
- D.DDD = Channel 3 Voltage
- E.EEE = Channel 4 Voltage
- F.FFF = Channel 5 Voltage
- G.GGG = Channel 6 Voltage
- H.HHH = Channel 7 Voltage
- XXX = CRC (ASCII Characters)
3.4 Concurrent Measurement Command

A concurrent measurement is one which occurs while other SDI-12 sensors on the bus are also taking measurements. This command is similar to the “aM!” command, however, the nn field has an extra digit and the sensor does not issue a service request when it has completed the measurement. Communicating with other sensors will NOT abort a concurrent measurement. Data values generated in response to this command are stored in the sensor's buffer for subsequent collection using "D" commands. The data will be retained in the sensor until another "M", "C", or "V" command is executed.

\[
\begin{array}{|c|c|c|}
\hline
\text{Command} & \text{Response} & \text{Description} \\
\hline
\text{"aC!"} & \text{"aC<CR><LF>"} & \text{Initiate measurement} \\
\hline
\end{array}
\]

Where:

- **a** is the sensor address ("0-9", "A-Z", "a-z", ",", ",?").
- **C** is an upper-case ASCII character.
- **ttt** is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have measurement data available in its buffer.
- **nn** is a two digit integer (00-99) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "D" commands.

The data recorder may wake the sensor with a break and collect the data anytime after the specified processing time has elapsed.

**Example of a H-4280 "aC!" command:**

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aC!&quot;</td>
<td>&quot;aC&lt;CR&gt;&lt;LF&gt;&quot;</td>
<td>3 sec</td>
<td>8</td>
<td>Make measurement</td>
</tr>
<tr>
<td>Subsequent Command</td>
<td>Response</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;aD0&quot;</td>
<td>a+A.AAA+B.BBB+C.CCC+D.DDD&lt;CR&gt;&lt;LF&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;aD1&quot;</td>
<td>a+E.EEE+F.FFF+G.GGG+H.HHH&lt;CR&gt;&lt;LF&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where:  
- A.AAA = Channel 0 Voltage  
- B.BBB = Channel 1 Voltage  
- C.CCC = Channel 2 Voltage  
- D.DDD = Channel 3 Voltage  
- E.EEE = Channel 4 Voltage  
- F.FFF = Channel 5 Voltage  
- G.GGG = Channel 6 Voltage  
- H.HHH = Channel 7 Voltage

---

**WATERLOG®**

H-4280  
SDI-12 Command and Response Protocol  3-5
3.5 Concurrent Measurement with CRC Command

The Concurrent Measure with CRC Command causes a measurement sequence to be performed with a CRC appended to the data. Data values generated in response to this command are stored in the sensor's buffer for subsequent collection using "D" commands. The data will be retained in the sensor until another "M", "C" or "V" command is executed.

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aCC!&quot;</td>
<td>&quot;attn&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>Initiate measurement</td>
</tr>
</tbody>
</table>

Where:
- **a** is the sensor address ("0-9", "A-Z", "a-z", ",", ",").
- **CC** are upper-case ASCII characters
- **ttt** is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have measurement data available in its buffer.
- **nn** is a two digit integer (00-99) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "D" commands.

The data recorder may wake the sensor with a break and collect the data anytime after the specified processing time has elapsed.

---

**Example of a H-4280 "aCC!" command:**

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aCC!&quot;</td>
<td>&quot;a0038&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>3 sec</td>
<td>8</td>
<td>Make measurement</td>
</tr>
</tbody>
</table>

Subsequent Command Response

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aD0&quot;</td>
<td>a+A.AAA+B.BBB+C.CCC+D.DDDXXX&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>&quot;aD1&quot;</td>
<td>a+E.EEE+F.FFF+G.GGG+H.HHHXXX&lt;CR&gt;&lt;LF&gt;</td>
</tr>
</tbody>
</table>

Where: A.AAA = Channel 0 Voltage
- B.BBB = Channel 1 Voltage
- C.CCC = Channel 2 Voltage
- D.DDD = Channel 3 Voltage
- E.EEE = Channel 4 Voltage
- F.FFF = Channel 5 Voltage
- G.GGG = Channel 6 Voltage
- H.HHH = Channel 7 Voltage
- XXX = CRC (ASCII Characters)
3.6 Send Data Command
The Send Data command returns sensor data generated as the result of previous "aM!", "aC!", or "aV!" commands. Values returned will be sent in 33 characters or less. The sensor's data buffer will not be altered by this command.

**Command**
"aD0!" through "aD9!"

**Response**
"apd...pd<cr><lf>"

Where:
- **a** is the sensor address ("0-9", "A-Z", "a-z", ",", "/").
- **D0..D9** are upper-case ASCII characters.
- **p** is a polarity sign (+ or -)
- **d.d** represents numeric digits before and/or after the decimal. A decimal may be used in any position in the value after the polarity sign. If a decimal is not used, it will be assumed to be after the last digit.

For example: +3.29   +23.5   -25.45   +300

If one or more values were specified and a "aD0!" returns no data (<CR><LF> only), it means that the measurement was aborted and a new "M" command must be sent.

**Example of a H-4280 "aD0!" command:**

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aM!&quot;</td>
<td>&quot;a0038&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>3 sec</td>
<td>8</td>
<td>Make measurement</td>
</tr>
</tbody>
</table>

**Subsequent Command**

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aD0&quot;</td>
<td>a+A.AAA+B.BBB+C.CCC+D.DDD&lt;CR&gt;&lt;LF&gt;</td>
</tr>
<tr>
<td>&quot;aD1&quot;</td>
<td>a+E.EEE+F.FFF+G.GGG+H.HHH&lt;CR&gt;&lt;LF&gt;</td>
</tr>
</tbody>
</table>

Where:
- **A.AAA** = Channel 0 Voltage
- **B.BBB** = Channel 1 Voltage
- **C.CCC** = Channel 2 Voltage
- **D.DDD** = Channel 3 Voltage
- **E.EEE** = Channel 4 Voltage
- **F.FFF** = Channel 5 Voltage
- **G.GGG** = Channel 6 Voltage
- **H.HHH** = Channel 7 Voltage
3.7 Continuous Measurements
Sensors that are able to continuously monitor the phenomena to be measured, such as a cable position, do not require a start measurement command. They can be read directly with the R commands (R0!...R9!). The R commands work exactly like the D (D0!...D9!) commands. The only difference is that the R commands do not need to be preceded with an M command.

The H-4280 does not support the aR0! continuous measurement command because the measurement and math operations require several seconds to complete.

3.8 Continuous Measurements
The H-4280 does not support the aR0! continuous measurement with CRC command.

3.9 Send Acknowledge Command
The Send Acknowledge Command returns a simple status response which includes the address of the sensor. Any measurement data in the sensor's buffer is not disturbed.

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;a!&quot;</td>
<td>&quot;a&lt;cr&gt;&lt;lf&gt;&quot;</td>
</tr>
</tbody>
</table>

Where: a Is the sensor address ("0-9", "A-Z", "a-z", "*", "?").

---

3-8 SDI-12 Command and Response Protocol
3.10 Initiate Verify Command
The Verify Command causes a verify sequence to be performed. The result of this command is similar to the "aM!" command except that the values generated are fixed test data and the results of diagnostic checksum tests. The data generated in response to this command is placed in the sensor's buffer for subsequent collection using "D" commands. The data will be retained in the sensor until another "M", "C", or "V" command is executed.

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aV!&quot;</td>
<td>&quot;atttn&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>Initiate verify sequence</td>
</tr>
</tbody>
</table>

Where:
- **a** is the sensor address ("0-9", "A-Z", "a-z", "*", "?").
- **V** is an upper-case ASCII character.
- **ttt** is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have data available in its buffer.
- **n** is a single digit integer (0-9) specifying the number of values that will be placed in the data buffer. If "n" is zero (0), no data will be available using subsequent "D" commands.

Example of a "aV!" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aV!&quot;</td>
<td>&quot;a0013&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>1 sec</td>
<td>3</td>
<td>Return fixed data and diagnostic data for testing purposes.</td>
</tr>
</tbody>
</table>

Subsequent Command Response

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aD0&quot;</td>
<td>a+123.456+78.9+y&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

Key Description Units
- +123.456 Fixed test data
- +78.9 Fixed test data
- y ROM checksum test 0 = Failed, 1 = Passed
3.11 Send Identification Command

The Send Identification Command responds with sensor vendor, model, and version data. Any measurement data in the sensor's buffer is not disturbed.

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aI!&quot;</td>
<td>&quot;allcccccccmmmmbv...xx&lt;cr&gt;&lt;lf&gt;&quot;</td>
</tr>
</tbody>
</table>

Where:

- **a** is the sensor address ("0-9", "A-Z", "a-z", "+", "/").
- **I** is an upper-case ASCII character.
- **ll** is the SDI-12 version compatibility level, e.g. version 1.2 is represented as "12".
- **ccccccc** is an 8 character vendor identification to be specified by the vendor and usually in the form of a company name or its abbreviation.
- **mmmmmm** is a 6 character field specifying the sensor model number.
- **vvv** is a 3 character field specifying the sensor version number.
- **xx...xx** is an optional field of up to a maximum of 13 characters to be used for serial number or other specific sensor information not relevant to operation of the data recorder.

Example of a "aI!" command:

"a12    DAA H-4280vvvS#nnnnnnVkkk<cr><lf>"

H-4280 implementation of the optional 13 character field:
*S#nnnnnnVkkk  (12 bytes total)*

Where:

- "nnnnnn" is a six character sensor serial number
- "kkk" is a three digit sensor firmware revision level
3.12 Change Sensor Address Command
The Change Sensor Address Command allows the sensor address to be changed. The address is stored in non-volatile EEPROM within the sensor. The H-4280 will not respond if the command was invalid, the address was out of range, or the EEPROM programming operation failed.

### Command Response Description

```
"aAn!  "n<cr><lf>"
```

Where:

- `a` is the current (old) sensor address ("0-9", "A-Z", "a-z", ",", ",", ",", "*"). An ASCII "*" may be used as a "wild card" address if the current address is unknown and only one sensor is connected to the bus.

- `A` is an upper-case ASCII character.

- `n` is the new sensor address to be programmed ("0-9", "A-Z").

**NOTE:** To verify the new address use the "Identify Command."

### Example of a "Change Sensor Address" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aA21&quot;</td>
<td>&quot;2&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>Change sensor address to &quot;2&quot;</td>
</tr>
</tbody>
</table>
3.13 Extended Read Channel_Config and Write Channel_Config

Each of the 8-input channels can be configured to make Unipolar/Bipolar and Single/Differential measurements. Use the “aXRC!” and “aXWC!” extended commands to monitor or change the configuration for each input channel. The Slope, Offset and SDI_Digits for each channel can also be configured with these commands.

The H-4280 always makes 8-measurements, even if one or more of the channels is configured for a differential measurement. For example: if Channel 0 is configured for a differential measurement, the Channel 0 measurement is determined by the input voltage on both Channel 0 & 1. Subsequently a measurement is made for Channel 1, with the results determined separately by the settings of Channel 1. Normally if Channel 0 is configured for a differential measurement, the results of the adjacent channel measurement (Channel 1) is ignored by the data logger (and vice versa).

<table>
<thead>
<tr>
<th>Channel Selection</th>
<th>Chan</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For differential measurements; if the (+) input will always more positive than the (-) input, set the channel to “unipolar”. The unipolar setting has the best resolution. If the (+) can be less positive than the (-) input, set the channel to “bipolar”. The bipolar setting allows the measurement to go negative but has the shortcoming of 1-bit less resolution.
The extended Read Channel_Config command prints a status message showing the settings for a selected channel. The response can be seen with most data loggers which implement a “transparent SDI-12" mode.

Command: "aXRCn!"

Where:  
- a is the sensor address ("0-9", "A-Z", "a-z", ",", ",?").
- XRC are upper case characters.
- n channel number (0-7)

The response is a message showing the current status of the channel settings.

Example of a H-4280 Extended "Read Channel Config" command:

Command & Response

0XRC5! Chan 5: Unipolar, Single, Digits=3, Slope=1.000, Offset=0.000

Where:

Unipolar 0 to 5.0 Volts - resolution is 0.3uV  
Bipolar: ±5.0 Volts - resolution is 0.6uV (Inputs must remain between 0 and +5V)  
Single Ended: Measurement is referenced to ground  
Differential: Measures the difference between two adjacent input channels (0-1, 2-3, 4-5, 6-7)  
Digits The number of digits to the right of the decimal point to be printed when making SDI-12 measurements  
Slope The “m” term in the y=mX+b function for this channel  
Offset The “b” term in the y=mX+b function for this channel
The “aXWCn!” extended command allows any (or all) of the configuration settings for a particular channel to be changed.

Command: "aXWCn <parameter list>!"

Where:
- a is the sensor address ("0-9", "A-Z", "a-z", "*", "?").
- XWC are upper case characters.
- n channel number (0-7)
- <parameter list> is one or more setup keywords

There must be a space between the channel # and the parameter list. Enter only the parameters you wish to change. Insert a space between each of the parameters. D=n, S=nnn, and O=nnn arguments must be entered with no embedded spaces. Do not enter two parameters which are mutually exclusive (such as both U and B). The following parameter keywords are recognized:

- **U** Unipolar
- **B** Bipolar
- **S** Single ended
- **D** Differential
- **D=** # of SDI-12 digits to the right of the decimal point (0-6)
- **S=**nnn The slope (m) term in the y=mX+b function for this channel (nnn = new slope value)
- **O=**nnn The offset (b) term in the y=mX+b function for this channel (nnn = new offset value)

The response to this command is a printout of the current settings as defined for the aXRCn! command described above.

**Example of a H-4280 Extended "Write Channel Config" command:**

**Command:**

```
0XWC2 B D D=4 S=2.0!
```

**Response:**

```
Chan 2: Bipolar, Differential, Digits=4, Slope=2.000, Offset=0.000
```
3.14 Extended Set_Current_Stage Command

The H-4280 processes each voltage measurement with a \( y = mX + b \) linear equation. During installation it is often convenient to quickly set the H-4280's measurement output to a certain value. For example, the output can be quickly set to match the current stage of a water elevation sensor as determined by a staff gauge or other datum. The “XSCS” extended command causes the H-4280 to make a fresh measurement and automatically update the Offset \( b \) term as needed to produce the desired value.

**Command**

"aXSCSn ddd!"

Where:
- \( a \) is the sensor address ("0-9", "A-Z", "a-z", ",", ",").
- XSCS are upper case characters
- \( n \) is the channel number (0-7)
- ddd is the new stage setting

(Note: there must be a space between the \( n \) and ddd arguments)

This command places 1 value in the data buffer. Use the “aD0" command to collect and view the current value.

**Example of a H-4280 Extended "Set Current Stage" command:**

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXSCS3 2.34!&quot;</td>
<td>&quot;a0031&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>3 sec</td>
<td>1</td>
<td>Set the Stage to 2.34</td>
</tr>
</tbody>
</table>

Subsequent Command | Response | Description |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aD0&quot;</td>
<td>a+12.80&lt;cr&gt;&lt;lf&gt;</td>
<td>The new Offset for channel 3</td>
</tr>
</tbody>
</table>
3.15 Extended Read/Write Offset and Read/Write Slope

The H-4280 processes the measurement data and computes the output value with a \( y = mx + b \) linear equation. The Slope (m) and Offset (b) terms are programmable, allowing the user to scale the reading into other engineering units. These commands allow the user to monitor or change the Slope and Offset terms. The Slope is set to 1.0 and the Offset to 0.00 at the factory. With the factory defaults the output will be in units of Volts. The new settings are stored in non-volatile EEPROM within the sensor. Once the new Slope or Offset value is written to the EEPROM, a copy is sent to the sensor data buffer for verification. This data can be viewed by using a subsequent "D" command. To verify these settings any other time, use the "XRSn" or "XROn" commands. This command takes 001 seconds to complete and places 1 value in the data buffer. Use the "aD0" command to collect and view the new slope or offset.

Command Response Description
"aXRSn!" "a0011<cr><lf>" Read Slope
"aXROn!" "a0031<cr><lf>" Read Offset
"aXWSn ddd!" "a0031<cr><lf>" Write Slope
"aXWOn ddd!" "a0031<cr><lf>" Write Offset

Where:
- a is the sensor address ("0-9", "A-Z", "a-z", "+", ",").
- XRS are upper case characters
- XRO are upper case characters
- XWS are upper case characters
- XWO are upper case characters
- n is the channel number (0-7)
- ddd is the new slope or offset value (For example: 20.0, 195 etc)

(Note: there must be a space between the \( n \) and ddd arguments)

---

### Example of a H-4280 Extended "Read Slope" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXRS5!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>1 sec</td>
<td>1</td>
<td>Read channel 5 Slope</td>
</tr>
</tbody>
</table>

Subsequent Command Response Description
"aD0!" "a+1.00<cr><lf>" Slope for channel 5 is 1.00

### Example of a H-4280 Extended "Write Slope" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXWS5 1.234!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>1 sec</td>
<td>1</td>
<td>Write channel 5 Slope</td>
</tr>
</tbody>
</table>

Subsequent Command Response Description
"aD0!" "a+1.234<cr><lf>" Slope for channel 5 is 1.234
3.16 Extended Read Mean_Count and Write Mean_Count

The H-4280 can make up to 80 measurements/second (per 8-channels). The module makes multiple high speed measurements, averages the results (simple mean) and reports one measurement per channel. The number of samples (Mean_Count) can be programmed from 1 to 255, the H-4280 comes from the factory configured to make 10 samples for each channel. The number of samples per measurement (1-255) is the same for all 8-channels.

The ttt field in the SDI-12 sensor response is computed by the H-4280 and indicates how much time the H-H4280 will require to complete the measurement sequence. The ttt field will automatically change if Mean_Count is changed.

The default ttt field is computed internally by the H-4280 as follows:

- Warmup time +1.0 sec
- Raw Measurements: +.125 sec (1/80 x 10)
- Math Overhead: +2.0 sec
- Round Upwards +1.0

- - - - - - -

- ttt 3.0 Seconds

Use the “aXRMC!” and “aXWMC!” extended commands to monitor or change the number of samples taken for each SDI-12 measurement.

Once a new Mean_Count value is written, a copy is sent to the sensor data buffer for verification. This data can be viewed by using a subsequent "D" command. To read or verify the value any other time, use the "XRMC" command.

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXRMC!&quot;</td>
<td>“a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>Read Mean_Count</td>
</tr>
<tr>
<td>&quot;aXWMCnnn!&quot;</td>
<td>“a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>Write Mean_Count</td>
</tr>
</tbody>
</table>

Where:
a is the sensor address ("0-9", "A-Z", "a-z", ".", ",", "?").

XRMC are upper case characters.

XWMC are upper case characters.

nnn is the number of raw measurements wanted.

This command takes 001 seconds to complete and places 1 value in the data buffer. Use the “aD0” command to collect and view the current value.
### Example of a H-4280 Extended "Read Mean_Count" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXRMC!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>1 sec</td>
<td>1</td>
<td>Read Mean_Count</td>
</tr>
<tr>
<td>&quot;aD0!&quot;</td>
<td>&quot;a+100&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td></td>
<td></td>
<td>Count = 100</td>
</tr>
</tbody>
</table>

### Example of a H-4280 Extended "Write Mean_Count" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXWMC16!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>1 sec</td>
<td>1</td>
<td>Write Mean_Count</td>
</tr>
<tr>
<td>&quot;aD0!&quot;</td>
<td>&quot;a+16&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td></td>
<td></td>
<td>Count = 16</td>
</tr>
</tbody>
</table>
3.17 Extended Read Power_Mode and Write Power_Mode

The H-4280 has a precision +5Vref excitation output terminal for powering potentiometers, thermistors and other sensors. The +5Vref output is normally turned off to save power while the module is in its sleep mode and is switched on before a measurement is made. If desired, the excitation output can be programmed to remain active while the module is asleep. Use the “aXRPM!” and “aXWPM!” extended commands to monitor or change the status of the excitation output while the module is in its sleep mode.

Once a new Power_Mode value is written, a copy is sent to the sensor data buffer for verification. This data can be viewed by using a subsequent "D" command. To read or verify the value any other time, use the "XRPM" command.

Command | Response | Description
--- | --- | ---
"aXRPM!" | "a0011<cr><lf>" | Read Power_Mode
"aXWPMn!" | "a0011<cr><lf>" | Write Power_Mode

Where: a is the sensor address ("0-9", "A-Z", "a-z", "*", "?").

XRPM are upper case characters.

XWPM are upper case characters.

n 0 = +5Vref is OFF during sleep
1 = +5Vref is ON during sleep

This command takes 001 seconds to complete and places 1 value in the data buffer. Use the “aD0” command to collect and view the current value.

### Example of a H-4280 Extended "Read Power_Mode" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXRPM!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>1 sec</td>
<td>1</td>
<td>Read Power_Mode</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aD0!&quot;</td>
<td>&quot;a+0&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>+5Vref is Off during sleep</td>
</tr>
</tbody>
</table>

### Example of a H-4280 Extended "Write Power_Mode" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXWPM1!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>1 sec</td>
<td>1</td>
<td>Write Power_Mode</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aD0!&quot;</td>
<td>&quot;a+1&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>+5Vref is On during sleep</td>
</tr>
</tbody>
</table>
3.18 Extended Read Warmup_Time and Write Warmup_Time

The H-4280 has a precision +5Vref excitation output terminal for powering potentiometers, thermistors and other sensors. The +5Vref output is normally turned off to save power while the module is in its sleep mode and is switched on before a measurement is made. The Warmup_Time is a programmable delay (1 to 999 seconds) which elapses before the first measurement is made. Use the “aXRWT!” and “aXWWT!” extended commands to monitor or change the warmup (wake up) time.

Once a new Warmup_Time value is written, a copy is sent to the sensor data buffer for verification. This data can be viewed by using a subsequent "D" command. To read or verify the value any other time, use the "XRWT" command. Do not set Warmup_Time to zero.

### Command Response Description

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXRWT!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>Read Warmup_Time</td>
</tr>
<tr>
<td>&quot;aXWWTnnn!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>Write Warmup_Time</td>
</tr>
</tbody>
</table>

Where: a is the sensor address ("0-9", "A-Z", "a-z", ":", "!").
XRWT are upper case characters.
XWWT are upper case characters.
nnn number of seconds

This command takes 001 seconds to complete and places 1 value in the data buffer. Use the “aD0" command to collect and view the current value.

#### Example of a H-4280 Extended "Read Warmup_Time" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXRWT!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>1 sec</td>
<td>1</td>
<td>Read Warmup_Time</td>
</tr>
</tbody>
</table>

#### Example of a H-4280 Extended "Write Warmup_Time" command:

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Time</th>
<th>Values</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aXWWT10!&quot;</td>
<td>&quot;a0011&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>1 sec</td>
<td>1</td>
<td>Write Warmup_Time</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Command</th>
<th>Response</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;aD0!&quot;</td>
<td>&quot;a+1&lt;cr&gt;&lt;lf&gt;&quot;</td>
<td>Warmup_Time time is 10 seconds</td>
</tr>
</tbody>
</table>
3.19 Extended “XTEST”
The “XTEST” command is used for installation or production testing and requires the use of a H-4191 Sidekick interface and a PC. This command causes the H-4280 to transmit unsolicited real-time data for testing purposes. The test mode is used to help troubleshoot the installation by providing a continuous readout of measurement data. This is not compliant with the SDI-12 specification and is not used with data loggers.

To activate the test mode, send the command “aXTEST!” from the PC. The H-4280 will enter the test mode and make and print continuous measurements. The test mode is exited by sending a break or any new command on the SDI-12 bus. It may take a few tries to exit if the command is sent at the same time data is being sent from the H-4280. Removing power from the H-4280 also causes it to exit this mode.

Example XTEST display:

```
0: +1.202 +3.222 +1.234 +2.345 +2.677 +3.333 +1.202 +1.202
0: +1.202 +3.222 +1.234 +2.345 +2.677 +3.333 +1.202 +1.202
0: +1.202 +3.222 +1.234 +2.345 +2.677 +3.333 +1.202 +1.202
0: +1.202 +3.222 +1.234 +2.345 +2.677 +3.333 +1.202 +1.202
```

etc.
## Appendix A
### Specifications

### Analog Inputs
- **Input Range:** 0-5.0 V max
- **Measurement:**
  - Unipolar: 0 - 5.0V
  - Bipolar: ±5.0V
  - Differential: 4-channels max
- **Resolution:** 24-bit,
  - 0.3uV (Unipolar)
  - 0.6uV (Bipolar)
- **Linearity Error:** ±0.5 LSB
- **Offset Error:** ±3 LSB
- **On channel leakage current:** ±1µA
- **Off channel leakage current:** ±1µA

### Sensor Excitation Output (& Internal A/D Reference)
- **Output Voltage:** 5.000V ±0.04%, switched off during sleep
- **Output Current:** 50mA max
- **Warmup Time:** Programmable, 1 to 999 seconds

### Data Processing
- **Averaging:** Programmable, 1 to 255 samples per channel
- **Sample Rate:** 80 samples/sec (all 8-channels)
- **User units:** y=mX+b (slope & offset)

### SDI-12 Port
- **Baud Rate:** 1200
- **Protocol:** SDI-12, 7-bit even parity, 1 stop bit
- **Output Voltage Levels:**
  - Minimum high level: 3.5 volts
  - Maximum low level: 0.8 volts

### Power Requirements
- **Voltage Input:** 6 to 16.0 Volts DC
- **Supply Current:**
  - Sleep Mode: 300µA typ
  - Active: 8mA typ
- **SDI-12 surge protection:** 1.5 KVA

### Environmental
- **Operating Temperature:** -40° C to +50° C
- **Storage Temperature:** -50° C to +70° C

### Mechanical
- **Material:** ABS plastic
- **Size:** 5.65" Long x 3.32" Wide x 1.25" Deep

### Connectors:
- **SDI-12:** 4-position plug-in terminal strip, Phoenix Combicon™ (provided)
- **Inputs:** 12-position plug-in terminal strip, Phoenix Combicon™ (provided)

### Warranty
The WATERLOG® H-4280 is warranted against defects in materials and workmanship for one year from date of shipment.

### Notes
Specifications subject to change without prior notice due to ongoing commitment to product testing and improvement.