



WATERLOG H-3301/3311

INCREMENTAL SHAFT ENCODER WITH SDI-12 AND QUADRATURE OUTPUTS



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CONTENTS & WARRANTY

This user manual is a guide for the H-3301/3311 shaft encoder. For more information, updated manuals, brochures, technical notes, and supporting software on the H-3301/H-3311 shaft encoder, please refer to waterlog.com or contact your sales representative.

For additional assistance, please contact us at +1.435.753.2212 or sales@waterlog.com

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Contents & Warranty

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01 / INTRODUCTION

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Adjust

Read

Pin	Color	Function
1	Blue	Water Level
2	Red	Water Level
3	Green	Water Level
4	Yellow	Water Level
5	Purple	Water Level
6	Orange	Water Level
7	Pink	Water Level
8	White	Water Level
9	Black	Water Level
10	Grey	Water Level
11	Light Blue	Water Level
12	Light Green	Water Level
13	Light Yellow	Water Level
14	Light Purple	Water Level
15	Light Orange	Water Level
16	Light Pink	Water Level
17	Light Grey	Water Level
18	Light White	Water Level
19	Light Black	Water Level
20	Light Blue	Water Level
21	Light Green	Water Level
22	Light Yellow	Water Level
23	Light Purple	Water Level
24	Light Orange	Water Level
25	Light Pink	Water Level
26	Light Grey	Water Level
27	Light White	Water Level
28	Light Black	Water Level
29	Light Blue	Water Level
30	Light Green	Water Level
31	Light Yellow	Water Level
32	Light Purple	Water Level
33	Light Orange	Water Level
34	Light Pink	Water Level
35	Light Grey	Water Level
36	Light White	Water Level
37	Light Black	Water Level
38	Light Blue	Water Level
39	Light Green	Water Level
40	Light Yellow	Water Level
41	Light Purple	Water Level
42	Light Orange	Water Level
43	Light Pink	Water Level
44	Light Grey	Water Level
45	Light White	Water Level
46	Light Black	Water Level
47	Light Blue	Water Level
48	Light Green	Water Level
49	Light Yellow	Water Level
50	Light Purple	Water Level
51	Light Orange	Water Level
52	Light Pink	Water Level
53	Light Grey	Water Level
54	Light White	Water Level
55	Light Black	Water Level
56	Light Blue	Water Level
57	Light Green	Water Level
58	Light Yellow	Water Level
59	Light Purple	Water Level
60	Light Orange	Water Level
61	Light Pink	Water Level
62	Light Grey	Water Level
63	Light White	Water Level
64	Light Black	Water Level
65	Light Blue	Water Level
66	Light Green	Water Level
67	Light Yellow	Water Level
68	Light Purple	Water Level
69	Light Orange	Water Level
70	Light Pink	Water Level
71	Light Grey	Water Level
72	Light White	Water Level
73	Light Black	Water Level
74	Light Blue	Water Level
75	Light Green	Water Level
76	Light Yellow	Water Level
77	Light Purple	Water Level
78	Light Orange	Water Level
79	Light Pink	Water Level
80	Light Grey	Water Level
81	Light White	Water Level
82	Light Black	Water Level
83	Light Blue	Water Level
84	Light Green	Water Level
85	Light Yellow	Water Level
86	Light Purple	Water Level
87	Light Orange	Water Level
88	Light Pink	Water Level
89	Light Grey	Water Level
90	Light White	Water Level
91	Light Black	Water Level
92	Light Blue	Water Level
93	Light Green	Water Level
94	Light Yellow	Water Level
95	Light Purple	Water Level
96	Light Orange	Water Level
97	Light Pink	Water Level
98	Light Grey	Water Level
99	Light White	Water Level
100	Light Black	Water Level

The WaterLOG® H-3301/3311 is a digital shaft encoder which measures water depth by monitoring the position of a float and pulley. The H-3311 has the same functionality as the H-3301 with the addition of a built-in display and manual offset adjustment feature making it easier to setup and use in the field. See Chapter-2 for details concerning the LCD display and offset adjust control.

The H-3301/3311 is easy to use and works with any SDI-12 data recorder. For older loggers, ALERT systems and the weather service LARK, the H-3301/3311 has a quadrature output that is equivalent to the Handar 436A type shaft encoder. The "Serial-Digital Interface" is ideal for data logging applications with the following requirements:

- Battery powered operation with minimal current drain
- Low system cost
- Multiple sensors on a simple three wire cable
- Up to 250 feet of cable between a sensor and the data recorder (Use of H-423, SDI-12 to RS485 converter extends the range to 1000's of feet)

The H-3301/3311 has the following features:

- Scales the encoder position into user units of feet, meters, etc.
- Precision dual bearing design with special low temperature lubricant
- Threaded shaft compatible with older mechanical shaft encoders
- Zero backlash
- 200 counts per revolution for the SDI-12 output
- Sealed enclosure protects from moisture and dirt
- Low current operation (less than 2 milliamps)
- High speed encoder circuitry prevents missing counts due to rapid float movement from wave action or sudden movement in freeze/thaw conditions - 15 ft/sec typical
- Water resistant connectors provide easy hookup

The LCD display on the H-3311 provides the following additional features:

- Continuous display readout always shows last measured value
- 'Read' button causes the H-3311 to continuously update the display while the button is pressed
- The adjust knob allows the user to manually set the stage
- The adjust knob allows the user to manually set the sensor SDI-12 address

Operation

The H-3301/3311 is a precision shaft encoder with a resolution of two hundred counts per revolution (0.005 ft with a 1 ft circumference pulley). The H-3301/3311 has an internal microprocessor controlled digital counter which monitors two digital outputs from a shaft position sensor. The sensor generates quadrature pulses and phase information. The phase information indicates which direction the shaft is turning. The H-3301/3311 continuously maintains a digital count representing the current position of the shaft. The H-3301/3311 counts to $\pm 32,768$ steps.

During normal operation, the SDI-12 data recorder sends an address followed by a measurement command to the H-3301/3311 sensor. The H-3301/3311 wakes up from its low power sleep mode, converts the shaft position into Feet, Meters or other units programmed for the stage measurement and stores this data in its data buffer. Once the data is ready, the data recorder collects the data from the H-3301/3311's data buffer.

INTRODUCTION

Programming The Data Recorder

You must prepare your data recorder to receive and record the H-3301/3311 data. Since data recorders differ widely, refer to your recorder manufacturer's directions. The H-3301/3311 maintains two values or parameters about the shaft position: the Stage in the selected engineering units and the Absolute Shaft Position in single unit steps. In general, program your data recorder to record one or two values from the H-3301/3311 via the SDI-12 port. Usually only the first value is recorded. The data recorder must issue an "aM!" command, then collect the data with a "aD0" command, as explained in Chapter 3. The H-3301/3311 places two data values in its data buffer:

a±XX.XX±NNNN

Where:

a	Is the the SDI-12 address 0-9, A-Z
XX.XX	Is the current encoder position (Stage) in user units (Feet, Meters etc.)
NNNN	Is the current absolute encoder position in units of steps (raw counts)

Programming The H-3301/3311

The H-3301/3311 comes from the factory with the following settings:

SDI Address: 0
Slope: 0.0050
Offset: 0.000

With these values Stage will be in units of feet when used with a pulley having a circumference of 12 inches. The slope value can be changed to accommodate other pulley circumferences or to change the data to other engineering units such as inches or Meters. The Address, Slope and Offset setup is stored in EEPROM within the H-3301/3311 and will not be lost if the power is disconnected. The extended commands for changing the slope, offset and sensor address are described in detail in Chapter 3. If more than one sensor is to be connected to the SDI-12 bus, make certain each sensor has a different sensor address.

Many applications use a shaft encoder to monitor water in a stilling well. A float and pulley translate the water level to rotation of the encoder's shaft. When the H-3301/3311 is installed, the encoder will be at a position determined by the current water level. When the H-3301/3311 is powered up it resets its internal position count to 0. All subsequent measurements will be relative to this initial position. If a measurement in absolute units or stage is wanted, you will need to change the OFFSET value to match the current stage as measured by a staff gauge or other datum.

Incremental encoders such as a quadrature encoders, monitor CHANGES in shaft position. With an incremental encoder, if the power is lost the encoder reference or zero position is also lost. The position count is maintained in RAM (not EEPROM) within the H-3301/3311. Storing the position in non-volatile (EEPROM) memory would not protect from power loss because encoder position changes would be missed during the loss of power. The H-3301/3311 protects its

position count with a software flag or “signature”. If the power is removed momentarily the H-3301/3311 will resume operation using the current position count. If the power is lost long enough to destroy the signature, when the power is restored the H-3301/3311 resets the position count to 0000. To intentionally reset the H-3301/3311’s position count, disconnect the power for 5 to 10 seconds.

A backup battery input is also provided to maintain shaft position during main power interruption or loss. Any shaft movements while main power is lost will still be recognized and when main power is restored the measured values will reflect the shaft changes while main power was lost. Without the backup battery the value would start again at 0.00 plus the current offset value.

With the shaft pointing toward you, rotating the encoder shaft counter-clockwise produces an increasing (positive) shaft position value. If this is backwards from your needs, either program the slope with a negative value for SDI-12 applications, or exchange the two quadrature connections to the shaft encoder for quadrature applications.

Installation

The H-3310/3311 is suitable for outdoor environments but must be installed in a protective enclosure or gauge house. Normally, the housing is screwed or bolted to a shelf in the gauge station with the pulley and tape protruding over the edge of the shelf above the water. Make certain the housing is level and the pulley and tape do not rub on any obstructions.

Making Output Connections

The H-3301/3311 has both a SDI-12 and quadrature outputs. The H-3301/3311 is an SDI-12 V1.3 compliant sensor. It connects directly to any data recorder with SDI-12 capability. In addition, the H-3301/3311 provides a raw quadrature output for use with other data recorders having a quadrature input.

The power for the H-3301/3311 is supplied by the SDI-12 +12V input. Table 1 shows the proper connections. Refer to the wiring diagram printed on the side of the H-3301/3311 for the connector pinout.

Table 1 Cable Connections		
Pin	Wire	Name
A	Red	+12V DC
B	Black	Ground
C	Green	Ground
D	Yellow	SDI-12 Data
E	Orange	Quadrature Phase A
F	Brown	Quadrature Phase B
G	Blue	Battery Backup

INTRODUCTION

Words of Caution

- Make certain the encoder's output does not go negative or more than +5.0 Volts
- Make certain the ground and power pins are connected to the encoder
- Keep the lead wires as short as possible
- Use shielded cables in noisy environments

Testing

After completing the installation, test the encoder by manually rotating the pulley. For the H-3311 press and hold the "Read" button to observe the display. Make certain the readout matches the expected measurement. For the H-3301 make an SDI-12 measurement and check for the expected measurement data.

02 /

H-3311 LCD DISPLAY



H-3311 LCD DISPLAY

Overview

The H-3311 has the same functionality as the H-3301 with the addition of a built in display and manual offset adjustment. The LCD display shows the last measured value. The display uses ultra low power and is always visible.

The offset adjustment is a rotary digital encoder and is accessed by removing the attached dust cover. The adjustment encoder has a screwdriver slot and is easily rotated with a screwdriver or other flat blade tool. Replace the dust cap whenever the adjustment is not being used.

Read Button Operation

The H-3311 has a 'Read' button that when pressed will cause the unit to continuously make measurements and update the display. The display will flash when the unit is making continuous measurements indicating the display is being updated even if the value is not changing. When the button is released the display will freeze with the last measured value displayed. Measurement requests from an attached SDI-12 data logger will also cause the display to update.

Using the Adjust Knob to Change Current Stage Value

While the 'Read' button is pressed, the Adjust screw may be turned to increase or decrease the current stage value. With a positive slope rotating the adjustment screw clock-wise to increment the value and counter-clock wise to decrement the value. Turning the Adjust screw slowly will change the thousandths digit while turning the screw fast changes the tenths digit. This allows one control to make both fine and course adjustments.

Using the Adjust Knob to Change SDI-12 Address

If the 'Read' button is held down while the H-3311 is being powered up, the display will show the current SDI-12 address. The SDI-12 address may be changed using the Adjust screw. Turning the Adjust screw will change the address in the range of 0 to 9. When the Read button is released the new SDI-12 address is saved and the display switches to the normal stage readout. To change the SDI-12 address again, the power must be disconnected and the special power-up sequence repeated.

03 / SDI-12 COMMAND & RESPONSE PROTOCOL

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Pin	Color	Function
1	White	Power
2	Green	Ground
3	Red	Power
4	Blue	Power
5	Black	Ground
6	Yellow	Power
7	Purple	Power
8	Brown	Power
9	Pink	Power
10	Grey	Power
11	Orange	Power
12	Light Blue	Power
13	Light Green	Power
14	Light Yellow	Power
15	Light Purple	Power
16	Light Brown	Power
17	Light Pink	Power
18	Light Grey	Power
19	Light Orange	Power
20	Light Light Blue	Power
21	Light Light Green	Power
22	Light Light Yellow	Power
23	Light Light Purple	Power
24	Light Light Brown	Power
25	Light Light Pink	Power
26	Light Light Grey	Power
27	Light Light Orange	Power
28	Light Light Light Blue	Power
29	Light Light Light Green	Power
30	Light Light Light Yellow	Power
31	Light Light Light Purple	Power
32	Light Light Light Brown	Power
33	Light Light Light Pink	Power
34	Light Light Light Grey	Power
35	Light Light Light Orange	Power
36	Light Light Light Light Blue	Power
37	Light Light Light Light Green	Power
38	Light Light Light Light Yellow	Power
39	Light Light Light Light Purple	Power
40	Light Light Light Light Brown	Power
41	Light Light Light Light Pink	Power
42	Light Light Light Light Grey	Power
43	Light Light Light Light Orange	Power
44	Light Light Light Light Light Blue	Power
45	Light Light Light Light Light Green	Power
46	Light Light Light Light Light Yellow	Power
47	Light Light Light Light Light Purple	Power
48	Light Light Light Light Light Brown	Power
49	Light Light Light Light Light Pink	Power
50	Light Light Light Light Light Grey	Power
51	Light Light Light Light Light Orange	Power
52	Light Light Light Light Light Light Blue	Power
53	Light Light Light Light Light Light Green	Power
54	Light Light Light Light Light Light Yellow	Power
55	Light Light Light Light Light Light Purple	Power
56	Light Light Light Light Light Light Brown	Power
57	Light Light Light Light Light Light Pink	Power
58	Light Light Light Light Light Light Grey	Power
59	Light Light Light Light Light Light Orange	Power
60	Light Light Light Light Light Light Light Blue	Power
61	Light Light Light Light Light Light Light Green	Power
62	Light Light Light Light Light Light Light Yellow	Power
63	Light Light Light Light Light Light Light Purple	Power
64	Light Light Light Light Light Light Light Brown	Power
65	Light Light Light Light Light Light Light Pink	Power
66	Light Light Light Light Light Light Light Grey	Power
67	Light Light Light Light Light Light Light Orange	Power
68	Light Light Light Light Light Light Light Light Blue	Power
69	Light Light Light Light Light Light Light Light Green	Power
70	Light Light Light Light Light Light Light Light Yellow	Power
71	Light Light Light Light Light Light Light Light Purple	Power
72	Light Light Light Light Light Light Light Light Brown	Power
73	Light Light Light Light Light Light Light Light Pink	Power
74	Light Light Light Light Light Light Light Light Grey	Power
75	Light Light Light Light Light Light Light Light Orange	Power
76	Light Light Light Light Light Light Light Light Light Blue	Power
77	Light Light Light Light Light Light Light Light Light Green	Power
78	Light Light Light Light Light Light Light Light Light Yellow	Power
79	Light Light Light Light Light Light Light Light Light Purple	Power
80	Light Light Light Light Light Light Light Light Light Brown	Power
81	Light Light Light Light Light Light Light Light Light Pink	Power
82	Light Light Light Light Light Light Light Light Light Grey	Power
83	Light Light Light Light Light Light Light Light Light Orange	Power
84	Light Light Light Light Light Light Light Light Light Light Blue	Power
85	Light Light Light Light Light Light Light Light Light Light Green	Power
86	Light Light Light Light Light Light Light Light Light Light Yellow	Power
87	Light Light Light Light Light Light Light Light Light Light Purple	Power
88	Light Light Light Light Light Light Light Light Light Light Brown	Power
89	Light Light Light Light Light Light Light Light Light Light Pink	Power
90	Light Light Light Light Light Light Light Light Light Light Grey	Power
91	Light Light Light Light Light Light Light Light Light Light Orange	Power
92	Light Light Light Light Light Light Light Light Light Light Light Blue	Power
93	Light Light Light Light Light Light Light Light Light Light Light Green	Power
94	Light Light Light Light Light Light Light Light Light Light Light Yellow	Power
95	Light Light Light Light Light Light Light Light Light Light Light Purple	Power
96	Light Light Light Light Light Light Light Light Light Light Light Brown	Power
97	Light Light Light Light Light Light Light Light Light Light Light Pink	Power
98	Light Light Light Light Light Light Light Light Light Light Light Grey	Power
99	Light Light Light Light Light Light Light Light Light Light Light Orange	Power
100	Light Light Light Light Light Light Light Light Light Light Light Light Blue	Power

SDI-12 COMMAND & RESPONSE PROTOCOL

This is a brief description of the Serial Digital Interface (SDI-12) Command and Response protocol used by the WATERLOG® Series Model H-3301/3311 sensor. Included is a description of the commands and data format supported by the H-3301/3311.

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.

During normal communication, the data recorder sends an address together with a command to the H-3301/3311 sensor. The H-3301/3311 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.

Standard SDI-12 Commands

Command	Description
aM!	Make Measurement
aMC!	Make Measurement with CRC
aC!	Make Concurrent Measurement
aCC!	Make Concurrent Measurement with CRC
aD0!	Send Data
aR0!	Make Continuous Measurement
aRC0!	Make Continuous Measurement with CRC
aV!	Verify Sensor
aAn!	Change Sensor Address
al!	Send Identification
a!	Send Acknowledge

Extended SDI-12 Commands Unique to the H-3301/3311

Command	Description
aXHELP!	Print a Command Listing
aXRS!	Read <i>Slope</i>
aXWSddd!	Write <i>Slope</i>
aXRO!	Read <i>Offset</i>
aXWOddd!	Write <i>Offset</i>
aXZ!	Zero the Position
aXTD!	Run a Check on the Display
aXSDddd!	Output a Specific Value to the Display
aXTEST!	Initiate a Repeating Test Printout

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.

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aM!"	"attn<cr><lf>"	Initiate measurement

Where:

- a is the sensor address ("0-9", "A-Z", "a-z", "*", "?").
- M is an upper-case ASCII character

SDI-12 COMMAND & RESPONSE PROTOCOL

- 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 anytime after the service request is received or the specified processing time has elapsed.

Example of an 'aM!' Command:

<u>Command</u>	<u>Response</u>	<u>Time</u>	<u>Values</u>	<u>Description</u>
'aM!'	"a0012<cr><lf>"	1 sec	2	Return encoder position
<u>Subsequent Command</u>	<u>Response</u>			
"aD0"	a+X.XX+NNNN<cr><lf>			

Where:

- X.XX = Current position (stage), in user programmable units
NNNN = Current position, in raw position counts

Measure Command with CRC

This "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.

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aMC!"	"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 anytime after the service request is received or the specified processing time has elapsed.

Example of an 'aM!' Command:

<u>Command</u>	<u>Response</u>	<u>Time</u>	<u>Values</u>	<u>Description</u>
'aMC!'	"a0012<cr><lf>"	1 sec	2	Return encoder position

<u>Subsequent Command</u>	<u>Response</u>
"aD0"	a+X.XX+NNNN<cr><lf>

Where:

X.XX = Current position (stage), in user programmable units

NNNN = Current position, in raw position counts

YYY = CRC (ASCII Characters)

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.

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aC!"	"atttnn<cr><lf>"	Initiate measurement

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.

Concurrent Measurement Command with CRC

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.

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aCC!"	"atttnn<cr><lf>"	Initiate measurement

SDI-12 COMMAND & RESPONSE PROTOCOL

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.

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.

<u>Command</u>	<u>Response</u>
"aD0!" through "aD9!"	"apd.d ... pd.d<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 (a<CR><LF> only), it means that the measurement was aborted and a new "M" command must be sent. The following is an example of the "aD0!" command.

Example of an "aD0!" command:

<u>Previous command</u>	<u>Response</u>
"aM!"	"a0012<cr><lf>"
<u>Subsequent Command</u>	<u>Response</u>
"aD0"	+X.XX+NNNN<cr><lf>

Where:

- X.XX = Current position (stage), in user programmable units
- NNNN = Current position (raw counts), in raw position counts

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-3301/3311 supports the aR0! continuous measurement command.

Example of an "aR0!" command:

<u>Command</u>	<u>Response</u>
"aR0!"	"a+X.XX+NNNN<cr><lf>

Where:

X.XX	= Current position (stage), in user programmable units
NNNN	= Current position (raw counts), in raw position counts

Continuous Measurements with CRC

The "Continuous Measurement with CRC" command makes a measurement sequence with a CRC appended to the data.

The H-3301/3311 supports the aRC0! continuous measurement command.

Example of an "aRC0!" command:

<u>Command</u>	<u>Response</u>
"aRC0!"	"a+X.XX+NNNNYYY<cr><lf>

Where:

X.XX	= Current position (stage), in user programmable units
NNNN	= Current position (raw counts), in raw position counts
YYY	= CRC (ASCII Characters)

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.

<u>Command</u>	<u>Response</u>
"a!"	"a<cr><lf>"

Where:

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

SDI-12 COMMAND & RESPONSE PROTOCOL

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.

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aV!"	"attn<cr><lf>"	Initiate verify sequence

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 an "aV!" command:

<u>Command</u>	<u>Response</u>	<u>Time</u>	<u>Values</u>	<u>Description</u>
"aV!"	"a0013<cr><lf>"	1 sec	3	Return fixed data and diagnostic data for testing purposes.

<u>Subsequent Command</u>	<u>Response</u>
"aD0"	a+123.456+78.9+y<cr><lf>

<u>Key</u>	<u>Description</u>	<u>Units</u>
+123.456	Fixed test data	
+78.9	Fixed test data	
y	ROM checksum test	0 = Failed, 1 = Passed

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.

<u>Command</u>	<u>Response</u>
"a!"	"allccccccmmmmmmvvvxx...xx<cr><lf>"

Where:

- a is the sensor address ("0-9", "A-Z", "a-z", "*", "?").
- l is an upper-case ASCII character.
- ll is the SDI-12 version compatibility level, e.g. version 1.3 is represented as "13".
- 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.
- mmmmm 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 an "a!" command:

"a12 DAAH-3301vvvS#nnnnnnVkkk<cr><lf>"

H-3311 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

Change Sensor Address

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-3301/3311 will not respond if the command was invalid, the address was out of range, or the EEPROM programming operation failed.

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aAn!"	"n<cr><lf>"	Change sensor address

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.

SDI-12 COMMAND & RESPONSE PROTOCOL

A is an upper-case ASCII character.

n is the new sensor address to be programmed ("0-9", "A-Z", "a-z", "*", "?").

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

Example of a "Change Sensor Address" command:

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aA2!"	"2<cr><lf>"	Change sensor address to "2"

Zero the Position Command

The "Zero Position" command resets the encoder position counter internal to the H-3301/3311. This allows for maximum counting range in both the clockwise and counter-clockwise directions.

When the H-3301/3311 is first powered up the position count is automatically reset to zero. After the unit has been powered up for some time, the Zero Position command provides a means to reset the position counter.

In most applications the initial position count will be at some undetermined value due to moving the encoder or adjustment of the float cables. Before programming the offset term (b) of the $mX+b$ data scaling equation it is important to zero the current position count. This preserves the maximum dynamic range of the H-3301/3311's 16-bit position counter (± 32768 raw counts). After the position counter is zeroed, program the $mX+b$ equation to obtain the desired stage using the extended write offset command ("aXWO").

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aXZ!"	"a<cr><lf>"	Zero the position counter

Where:

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

XZ are upper case characters

This command takes 000 seconds to complete and places no data in the data buffer.

Example of an Extended "Zero the Position" command:

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aXZ!"	"a<cr><lf>"	Reset encoder position

Read User Offset and Read User Slope Commands

The H-3301/3311 processes the raw shaft encoder position with a $mX+b$ equation. The slope (m) and offset (b) terms are programmable, allowing the user to scale the position into other engineering units. These commands allow the user to read the current slope and offset terms.

The slope is set to 0.005 and the offset to 0.000 at the factory. The H-3301/3311 has a mechanical position resolution of 200 counts per revolution. When used with a pulley 1.0 feet in circumference: $0.005 \text{ feet/count} \times 200 \text{ counts/rev.} = 1.0 \text{ feet/rev.}$ The slope term can be changed for other pulley diameters or for other units such as inches or meters.

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aXRS!"	"a0011<cr><lf>"	Read Slope
"aXRO!"	"a0011<cr><lf>"	Read Offset

Where:

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

XRS are upper case characters.

XRO are upper case characters.

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

Example of an Extended "Read User Units Slope" command:

<u>Command</u>	<u>Response</u>	<u>Time</u>	<u>Values</u>	<u>Description</u>
"aXRS!"	"a0011<cr><lf>"	1 sec	1	Read Slope

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aD0!"	"a+0.005<cr><lf>"	Slope Reading is 0.005

Pulley Circumference	Units	Slope
12in	ft	0.005
18in	ft	0.0075
375mm	m	0.001875
750mm	m	0.00375

SDI-12 COMMAND & RESPONSE PROTOCOL

Write User Offset and Write User Slope Commands

The H-3301/3311 processes the raw shaft encoder position with a $mX+b$ equation. The slope (m) and offset (b) terms are programmable, allowing the user to scale the encoder position into other engineering units. This command allows the user to write (change) the slope and offset terms. The new value is 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 the Slope or Offset any other time, use the "Read User Slope" or "Read User Offset" commands.

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aXWSddd!"	"a0011<cr><lf>"	Write Slope
"aXWOddd!"	"a0011<cr><lf>"	Write Offset

Where:

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

XWS are upper case characters.

XWO are upper case characters.

ddd is the new slope or offset value. The input format is very flexible. Some examples are shown below.

20.0
0.195
-500

Example of an Extended "Write User Units Slope" command:

<u>Command</u>	<u>Response</u>	<u>Time</u>	<u>Values</u>	<u>Description</u>
"aXWS1.234!"	"a0011<cr><lf>"	1 sec	1	Write Slope

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aD0!"	"a+1.234<cr><lf>"	Slope verified at 1.234

Test Display

This command tests the individual segments of the display by cycling through the numbers 0-9 in each of the different positions on the display followed by displaying the numbers 100, 1000 and 10000 to test the decimal locations.

<u>Command</u>	<u>Response</u>	<u>Description</u>
"aXTD!"	"a0200<cr><lf>"	Test Display

Where:

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

XTD are upper case characters.

Appendix A Specifications

General

Input: Shaft Position
 Outputs: SDI-12 & 2-Wire
 Quadrature

Resolution (SDI): 200 counts/rev
 Resolution (Quadrature): 100 counts/rev

Max rate: 15 rev/sec

Quadrature Output

Type: Open Drain
 (optional factory installed
 pull up resistor to 5.0 V)
 Transient Protection: 5.0V Transguard

SDI-12 Output

Baud Rate: 1200
 Protocol: SDI-12, 7-bit even parity,
 1 stop bit
 Version: 1.3
 Output Voltage Levels:
 minimum high level: 3.5 volts
 maximum low level: 0.8 volts
 maximum cable length: 250 ft.

Power Requirements

Voltage Input: 9.6 to 16 Volts DC
 Current: Less than 2.0mA

Environmental

Operating Temperature: -40 to 60 °C
 Storage Temperature: -50 to 70 °C
 Humidity: 0 to 100%

Mechanical

Bearing: Double bearing with
 external seal and 1.12 in.
 separation
 Starting Torque: 0.15 oz in typical
 0.50 oz in max over
 temperature
 Shaft: 5/16 in. compatible with
 Stevens, Fisher and Porter
 pulleys and accessories
 Shaft Length: 2.00 in.
 Shaft Clearance: 1.75 in.
 Shaft Tread: 24 threads per in.
 Thread Length: 0.75 in.
 Material: Anodized Aluminum
 Size: 7 in. wide (base plate)
 4-1/4 in. high
 4 in. deep (not including
 shaft or connectors)

Connector

Bulkhead: Amphenol MS3102R16S-1P
 (7-pin male)
 Cable: Amphenol MS3106A16S-1S
 (7-pin female)

(One cable provided with the H-3301/3311)

Warranty

The WaterLOG® H-3301/H-3311 is warranted against defects in materials and workmanship for two years from the date of shipment.

Xylem

- 1) The tissue in plants that brings water upward from the roots;
- 2) a leading global water technology company.

We're 12,000 people unified in a common purpose: creating innovative solutions to meet our world's water needs. Developing new technologies that will improve the way water is used, conserved, and re-used in the future is central to our work. We move, treat, analyze, and return water to the environment, and we help people use water efficiently, in their homes, buildings, factories and farms. In more than 150 countries, we have strong, long-standing relationships with customers who know us for our powerful combination of leading product brands and applications expertise, backed by a legacy of innovation.

For more information on how Xylem can help you, go to www.xylem.com



YSI Incorporated
1700/1725 Brannum Lane
Yellow Springs, Ohio, 45387, USA

Request a Quote
Tel: +1.435.753.2212
Email: sales@waterlog.com
Internet: www.waterlog.com

Place an Order
Tel: +1.937.767.7241
Email: orders@ysi.com

Customer Support
Tel: +1.937.767.2772