AMASS DATA
TECHNOLOGIES INC.

PSE-SDI(\D)(\Ev)

Pliant Shaft Encoder (SDI-12 Device)
including the Display option

User Reference Manual

Firmware supplied after January 1, 2001
Hardware D1

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http://www.amassdata.com

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Pliant: readily yielding to influence

1.   AMASSER SDI-12 Shaft Encoder

The ///AMASSER Incremental Shaft Encoder is an intelligent and reliable microprocessor-based incremental shaft encoder which may be used with a pulley, tape, and float arrangement to measure stream stage or other fluid levels.   It is also an integral part of the PARSE (Pliant Automatic Reeler with Shaft Encoder) ground-water level sensor.   Accumulating position data adaptively (hence *pliant*), up to one thousand times per second results in a drastic power consumption reduction.

The standard unit, the PSE-SDI, provides data by means of a SDI-12 cable (see 2 SDI-12 Protocol) connected to a Data Collection Platform (DCP) or personal computer. "Rev D" units, and later, are configurable to either standard SDI-12 or RS485-based SDI-12. RS485-based SDI-12 allows communications up to 4000 feet! (see section 5.4). Options are available as per section 1.2 The Options.

The resolution of the encoder is 1/384th of a revolution (standard); when used with a stream stage pulley with a 375 mm circumference, the resolution of the system is 0.98 mm. When used with a 12.00 inch-circumference pulley, the resolution of the system is 0.03125 inches or 0.0026 feet. It is a two channel optical incremental encoder that contains a lensed LED source, integrated detectors, and a codewheel which rotates between the emitter and the detector. The PSE firmware provides a pulsed LED driver with an adaptive firmware based signal transition detector that provides the 4x quadrature decoder function.   This technique of the processor, in conjunction with idle power-down mode, drops the system's current consumption down to about 5mA in quiescent mode (non-display models, see 1.2 The Options).

 Hardware is powered from a +10.5 to 15 V input for external battery, charger or power supply. A 256byte EEPROM provides non-volatile storage of the device address as well as the encoder scale and offset. A 9 V alkaline battery provides backup for a total of approximately 130 hours in the event of power supply interruption.

There are no mechanical contacts involved in the measurement process; the only contacting moving parts are the precision shaft bearings. The starting torque is low -- 0.65 inch-oz (47 cm-g) or less -- and the system is not sensitive to vibration. It is housed in a painted aluminum case, and may be installed in exposed locations. It is tested to operate from -40C to +55C, and up to 100% relative humidity.

1.1. Quadrature Encoder -Principle of Operation

The PSE-SDI(\D) is provided with an on-board 89C52 microcontroller and firmware which follows the shaft rotation; each transition of either of the quadrature inputs adds or subtracts a count to a 16 bit stored value representing the position of the shaft and therefore the fluid level. A set-up parameter called *scale* is provided to allow the application of a standard-circumference pulley and tape so that the accumulated count represents an accurate fluid level. If using a 1 ft-circumference pulley for instance, the accumulated count would directly indicate a fluid level in feet by setting the scale = 1.0. The SDI-12 output from the microprocessor is the ASCII code representation calculated to three decimal places and is equal to the position value stored in the internal register divided by 384 (Model K encoder). Communication with an external controller or computer is according to the SDI-12 protocol. The output will be a decimal value in the range +/-999.999 units.

The encoder's **scale** and **offset** are set using SDI-12 commands, for example, if you are using a 375 mm wheel your **scale** must be 0.375 and the output will be in units of meters measured to the nearest mm (see section 3.3.2. Set Encoder *Scale* (units per revolution)). The value of **offset** is set to the current water level with respect to your benchmark. You may opt to enter an **offset** with respect to sea level. For example, you would enter '101.225' if the water level at set-up time is 101.225 above sea level.   All subsequent readings would be interpreted as 'level above seal level' (see section 3.3.1. Set Encoder *Offset*).

1.2. The Options

In addition to the features provided by the standard unit are the following options:

The "**\D**" option: Provides an 8-digit display with switches that provide an additional interface to the SDI-12 communications. Viewing as well as configuring parameters can be accomplished via the display interface (see section 4 PSE-SDI\D Display Operation).

The "**\Ev**" option: Provides one event counter that is configurable to your needs (see section 3.2.3 Get Event Counter Value).

The optional digital display enables the user to display and set up parameters without the need for a DCP or portable computer. These setup parameters are as follows: the offset and scale of the encoder, the scale and mode of the event counter (\Ev models only) as well as the node address for SDI-12 communications. Note that the display also allows the user to enter the password that is required to access the setup parameters via the display. When not setting these parameters the display provides the instantaneous position of the encoder , i.e. the water level (see 4 PSE-SDI\D Display Operation)

2. SDI-12 Protocol

The Master SDI-12 controller, which may be a portable computer or a DCP equipped with a SDI-12 serial interface, sets an initial offset and units per revolution values for the adaptive quadrature counter and initialises the microcontroller. Commands available to the encoder are listed in the *SDI-12 AMASSER SE Sensor Commands* section. A single computer or controller can supervise an array of up to 10 Incremental Encoders along the 3-wire SDI-12 cable.

The internal microprocessor is normally in an "idle" state; the internal firmware wakes the processor at up to one thousand times per second in order to check the value of the two quadrature outputs from the optical encoder. The polling rate on the SDI port is controlled by the host DAS or DCP.

In order to communicate with a sensor, the controller sends a "break" signal, which consists of sending a spacing signal (5 V) for more than 12 millisec. This will wake all sensors connected to the line. The controller then sends a command selected from below. The format of each byte of data is 1 start bit, 7 data bits with the least significant bit first, 1 parity bit with even parity, and 1 stop bit. The first significant byte of any message is the address of the sensor; all sensors with different addresses return to the "sleep" state and ignore the rest of the command. The last character of a command is always "!", and the controller turns off its transmitter within 7.5 millisec after sending the "!". The sensor responds by setting the data line to marking (0 V) for 8.33 millisec, and then begins its response. The first bit of the response must be sent within 15 millisec of receiving the last byte of the command.

The ///AMASSER PSE-SDI(\D) Shaft Encoder maintains in its memory a number which represents the current value of the water level, stream stage, or other quantity being measured. Upon receiving the "Measure" (aM!) command, it transfers the current value to the output buffer in the required ASCII format based on the offset and scale parameters; and upon receiving the "Send Data" (aD!) command, the value from the output buffer is sent to the controller.

For detailed information on SDI-12 protocol visit the SDI-12 Support Group's at http://www.sdi-12.org.

3.   SDI-12 AMASSER SE Sensor Commands

The PSE-SDI(\D)(\Ev) is SDI-12 compatible and as such follows the guidelines set out in that protocol.

3.1. SDI-12 Command Symbols

a : address byte

! : Terminates the command

<cr> : The carriage return character which is represented as '\0d' in the ASCII string.

<lf> : The line feed character which is represented as '\0a' in the ASCII string. All responses are terminated with <cr><lf>.

Command bytes : one or two byte ASCII character command. Ex.: M0

Identification String : "13AMASS Data PSExxx" where xxx = Revision Level

3.2. Retrieve Data Commands

3.2.1. Get Encoder Value In Scaled Units
- command: aM!, aM0!, aC! or aC0!
- response: a0001<cr><lf> data buf: <encoder value>

This command instructs the PSE-SDI(\D) unit to measure the current shaft encoder position. The SDI-12 format for the response to this command is : atttn<cr><lf>. As always 'a' is the address byte, 'ttt' is the specified time, in seconds, until the sensor will have the measurement(s) ready and 'n' is the number of measurement values the sensor will make and return in one or more subsequent D commands (see *Return data buffer* below).   The implementation of this command to the PSE-SDI(\D) yields the response shown above. 'ttt' indicates that the measurement is immediately available for retrieval (000) and 'n' that there was only one measurement made, namely, the encoder value.   The measurement is then retrieved using the D! command.

Note that aM! and aM0! are *start measurement* commands whereas aC! and aC0! are *start concurrent measurement* commands. The C commands are favored when a sensor specifies a measurement time of several seconds as they allow the user to send additional commands in the interim. For the encoder measurement, however, the two types are equivalent since it specifies a time of 0 seconds.

Example:

The current sensor address is 0 and you wish to obtain the current encoder position.

Command: 0M! or 0M0!
Response: 00001\0d\0a

This response indicates that the measurement is immediately retrievable from the buffer and that there was only one measurement made, the encoder position, which may now be retrieved using the D command.

3.2.2. Start Verification Command

- command: aV! or aV0!
- response: a+<data buffer 1>+<data buffer 2>+ <data buffer 3><cr><lf>

This command is used to monitor the power supply status of the unit. The data buffers are defined as follows:

Data Buffer 1 EEPROM	Data Buffer 2 Processor Power Supply	Data Buffer 3 Mode of the Event Counter
1 (Operational) or 0 (Failure)	1 (Operational) or 0 (Failure)	0 to 3

Example:

The current sensor address is 0 and you want the status of the power.

Command: 0V! or 0V0!
Response: 0+1+1+0\0d\0a

This would indicate that no power interruptions occurred since the last 'verification' and that the event counter is currently set to mode '0' (see section 3.3.4).

3.2.3. Get Event Counter Value

- command: aM3! or aC3!
- response: a0001<cr><lf>

PSE-SDI(/D) units shipped after January 1, 2001 include one event counter. The 'M3' or 'C3' commands instruct the PSE-SDI(/D) to return the current number of counts of the built-in event counter. The event counter is used with sensors that produce switch closures such as tipping buckets, or sensors that emit pulses. The event counter is user-configurable as per section 3.3.4 Set *Mode* of Event Counter.

Example:

The current sensor address is 2 and you wish to obtain the current number of counts.

Command: 0M3!
Response: 00001\0d\0a

This would indicate that the data buffer contains the current number of counts and is ready for retrieval by sending a 'D' command (see section 3.2.5 Return Data Buffer).

3.2.4. Get Average, Max/Min Encoder Position

- command: aM5! or aC5!
- response: attt1<cr><lf> where ttt= (number of samples X sampling period)+1 sec
                    data buf <average encoder position>

       This command initiates a measurement of the average, maximum and minimum encoder position using the parameters defined by the 'S6' command. The 'S6' command defines the number of samples and the sampling period to be used for average measurements. The time-limit 'ttt' is a function of the user-defined values for the 'number of samples' and the 'sampling period'.   See section 3.3.6 Set Averaging Parameters.

Example:
       The current host address is 3 and you wish to obtain the average encoder position. The user has previously sent a 'S6' command specifying that average measurements be obtained using, say, 10 samples that are 1 second apart. All subsequent 'M5' commands will determine the average based on the current 'S6' settings (10 samples that are 1 second apart):

       Command: 3M5!
       Response: 30111\0d\0a
       Command: 3D0!
       Response: 3+1.111+1.125+1.102\0d\0a

Therefore the average position= +1.111, maxi= +1.125 and min=1.102.   The format is thus "address+average+maximum+minimum". Note, however, that the max and min value are swapped when the scale is set to a negative value.   As always with the 'M' commands, the 'D' command must be issued to retrieve the data. Note that the *Response Time* (in this case 11 seconds) is a function of the number of samples and the sampling period as configured by the 'S6' command (section 3.3.6).

3.2.5. Return Data Buffer

- command: aD! or aD0!
- response: a<data buffer><cr><lf>

       This command allows the user to read the most recent sensor measurement which was stored in the buffer. It is issued after an M, C or V command and as such is used to read the instantaneous encoder position, the minimum, maximum and average encoder positions as well as the event counter value.

Example:
       The current host address is 0 and the last "Measure" command was 0M0!. The response would typically be as follows:

       Command: 0D0!
       Response: 0+2.345\0d\0a

This indicates that the encoder position was +2.345 at the moment the 0M0! command instructed the unit to take a measurement. Note that values returned from the buffer are expressed in engineering units that were defined by the user at set-up time. For instance, if the encoder offset and scale had been set to 0.0 m and +0.375m/rev respectively, the position of +2.345 in this example would represent a rise in fluid levels in meters.

3.2.6. <u>Return Identification String</u>

- command: aI!
- response: a\<identificationstring\>\<cr\>\<lf\>

This command instructs the PSE-SDI(\D)to return its identification string.   The SDI-12 format for the response to this command is : allcccccccccmmmmmmvvvxxx…xx\<cr\>\<lf\>.   'll' is the SDI-12 version number indicating SDI-12 version compatibility ; for example, version 1.3 is encoded 13. 'ccccccc' is the vendor identification (ex: AMASSData), 'mmmmmm' is the sensor model (ex: PSE), 'vvv' is the sensor version number (ex: 024) and 'xxx…xx' is an optional field not currently used.

<u>Example:</u>
The current host address is 0 and you wish to obtain the identification string.

Command: '0I!'
Response: '013AMASSDATA PSE070\0d\0a'

Therefore the sensor is manufactured by AMASS Data Technologies Inc, it is a PSE-SDI version 070 and is compatible with SDI-12 version 1.3.

3.2.7. <u>Acknowledge Active Command</u>

- command: a!
- response: a\<cr\>\<lf\>

This command allows the user to confirm that the current host address is active.

<u>Example:</u>
The current host address is 3 and you would like confirmation that it is active.

Command: '3!'
Response: '3\0d\0a'

This response is confirmation that host address 3 is active.

3.2.8. <u>Address Query Command</u>

- command: ?!

- response: a<cr><lf>

This command allows the user to obtain the current node address. This command is simply the *acknowledge active* command but substituting the '?' as a wild card for the host address. The result of this "wild card" feature is that a sensor will respond regardless of its node address. The user must realize, however, that if more than one sensor is connected to the bus, they will all respond, causing a bus contention. An SDI-12 sensor must support the wild card character '?' with the *acknowledge active* command and can, but only optionally, similarly support all other commands.

Example:
There is only one sensor on the bus and you wish to obtain its node (device) address.

Command: ?!
Response: 6\0d\0a

The address of the sensor is therefore 6. To resume communications the host address can be updated to 6 or simply left at ?.

3.2.9. Change SDI Device (Node) Address
- command: aA<new address>!
- response: <new address><cr><lf>

This command changes the node address. In order to communicate with the PSE-SDI(\D)the host and node addresses must be the same which makes it is necessary to update the host address following a change of node address.

Example:
The current host (and node) address is 4 and you wish to change the node address to 6.

Command: '4A6!'
Response: '6\0d\0a'

This response confirms that the new node address is 6. The host address must now be updated to 6 in order to communicate with the PSE-SDI(\D)(\Ev). The user can then confirm that the new host address is active by sending the *acknowledge active* command.

3.2.10. Query Command

- command: aQ0!, aQ1!, aQ2!, aQ3!, etc…
- response: a<information string><cr><lf>

        The Query Command Q allows the user to determine the current value of the set-up parameters. To obtain the full configuration of the unit simply transmit orderly Q commands (that is, Q1, Q2, Q3, etc…) until a response of '0' is obtained (refer to SDI-12 spec version 1.3). The following example is fully explanatory.

<u>Example:</u>
        The current address is 0 and you wish to obtain the full configuration of the PSE-SDI.

        Command: '0Q0!'
        Response: '0+1.123 Offset/S0\0d\0a'
        Command: '0Q1!'
        Response: '0+0.375 Scale/S1\0d\0a'
        Command: '0Q2!'
        Response: '0+0 EvCntr Mode/S2\0d\0a'
        Command: '0Q3!'
        Response: '0+1.000 EvCntrScale/S3\0d\0a'
        Command: '0Q4!'
        Response: '0+010 AvInterval/S6\0d\0a'
        Command: '0Q5!'
        Response: '0+010 Av# of samples/S6\0d\0a'
        Command: '0Q6!'
        Response: '0\0d\0a'

Note that each parameter is followed by its corresponding 'S' command for easy reference. For example, the response '0+1.123 Offset/S0\0d\0a' indicates that the encoder offset is configured using the 'S0' command and that its current value is +1.123.

3.2.11. Read Value of Set-up Parameter

- command: aS0?! or aS1?! or   aS6?!
- response: a<data buffer><cr><lf>

This command is similar to the Query command (section 3.2.10). It enables the user to read the current value of any given set-up parameter. Its use is simple. Simply send the command normally used for setting the parameter in question but substitute the data value with the character '?'.

Examples:
     1. The current sensor address is 3 and you wish to determine the current value of the shaft encoder "scale".

     Command: '3S1?!'
     Response: '3+0.375\0d\0a'

The current value of the shaft encoder scale is therefore "+0.375". Recall that the value for the parameter "scale" represents the engineering units equal to one revolution of the shaft and is equal to the circumference of the pulley mounted on the shaft. Therefore "+0.375" might represent 0.375 meters per revolution. Also recall that a positive value for "scale" represents a clockwise rotation of the shaft for rising water levels. Refer to 3.3.2.

     2. The current sensor address is 5 and you wish to determine the parameters used for measuring average encoder positions.

     Command: '5S6?!'
     Response: '5+5+15\0d\0a'

Therefore, a sampling period of 0.5 seconds (5 X 100msec = 0.5 sec) and 15 samples are used for determining average encoder positions. See section 3.3.6 Set Averaging Parameters.

3.3. <u>Set Commands</u>

3.3.1. <u>Set Encoder *Offset*</u>

- command: aS0<offset>!
- response: a<cr><lf>

This command sets the initial position or offset of the encoder.

<u>Example:</u>

The current host address is 5 and you wish to set the encoder to measure the elevation above sea level. You would measure your stage at set-up time and enter the offset accordingly. For instance, if the stage level is measured as 101.225 meters above sea level you would enter 101.225 as an offset. All levels measured by the PSE-SDI(\D)would then be in meters above sea level.

Command: 5S0+101.225!
Response: 5\0d\0a

3.3.2. <u>Set Encoder *Scale* (units per revolution)</u>

- command: aS1<scale>!
- response: a<cr><lf>

This command sets the encoder scale according to the size of pulley in use and the direction of shaft rotation. Note that the offset and scale must be set with consistent engineering units, usually ft or m. In addition, when initializing the scale the user must be aware of the direction of shaft rotation with respect to water levels. <u>Clockwise rotation of the pulley represents rising water levels when the scale is positive, otherwise the scale must be set negative.</u>

<u>Example:</u>

The current host address is 4 and you wish to initialize the encoder scale. The pulley is 375 mm in circumference and the shaft turns counter-clockwise with rising water levels.

Command: 4S1-.375!
Response: 4\0d\0a

Note that the scale is entered in meters because the water levels will be measured in meters (not mm). Also note that the scale is entered as a negative value because in this instance the shaft turns counter-clockwise when the water level is rising.

3.3.3. Set *Scale* of the Event Counter

- command: aS3+<scale>!
- response: a<cr><lf>

This command is used to set the *scale* of the event counter. The *scale* is set according to the application in question. For instance, with tipping buckets the scale can be set to the amount of rain that each count represents as per the documentation of the sensor. The engineering unit that is used for the *scale* will also represent the event counter value.

The following range of values may be used for the scale: $0.001 <$ range < 32.766. Negative values cannot be used for the scale.

Example:

The current host address is 7 and you wish to set the scale of the event counter for a tipping bucket which has 0.01"(0.25mm)/tip.

Command: 7S3+0.01!
Response: 7\0d\0a

This response confirms that the scale has been successfully set. The event counter readings will henceforth represent inches of rain.

3.3.4. Set *Mode* of Event Counter

- command: aS2+<mode of the event counter>! (refer to APPENDIX B for mode codes)
- response: a<cr><lf>

This command is used to set the mode for the event counter. The mode-selection feature of the event counter allows the user to configure the system to a particular application. The modes that are available are as follows: **Pulse** versus **Switch Closure** modes and **Read/Reset** versus **Overflow** modes.

The **Switch Closure** mode features a "debouncing" capability that is required in order to obtain an accurate count with switches that produce a "noisy" signal. Mechanical switches must be used in Switch Closure mode unless they are "debounced" externally. This mode is limited to a frequency of 10 Hz.

The **Pulse** mode is to be used with switches that generate electronic pulses, i.e. noiseless signals. This mode allows reliable readings up to a frequency of 5 kHz.

The last two options are presented as a means to control whether or not the event counter is reset upon retrieval. For instance, if the PSE-SDI(\D) is to be operated by multiple users with a portable computer you may want the event counter to maintain a cumulative count which is not cleared when read; this would require setting them to **Overflow** mode.   Alternatively, if the unit is accessed by a data logger which provides date/time stamping the **Read/Reset** mode is suitable. While in the Read/Reset mode the event counter is automatically reset to zero when retrieved with an M, C (subsequently D) or R command. Therefore it is the user's responsibility to record the event counter readings upon retrieval since these are then automatically erased. If the event counter should ever reach the 16-bit maximum (65535) it overflows and starts over again.

Note that the event counter can be reset "manually" by using the 'S5' command as per section .

Note that the event counter uses a 16-bit register (i.e. up to 65535 counts). In the event that the counter should overflow, the reading should be interpreted appropriately as follows: if the last reading was 64300 and the current reading is 1200, the actual count would be (65536 - 64300) + 1200 = 2436 counts.

The modes are represented internally as a 2-bit number as defined in the following table. The mode code is the decimal representation of this number and is converted in APPENDIX B as a convenience for the user.

Bit 1	Bit 0
Read/Reset (1) or Overflow (0)	Pulse (1) or Switch Closure (0)

The codes are from 0 to 3 inclusively as per the table above. Note that the current mode of the event counter can be determined with the V command (see section 3.2.2 Start Verification Command).

<u>Example:</u>
The current address is 3 and you wish to set the event counter to Pulse and Read/Reset modes. The table shows that this corresponds to "11" which translates to a mode code of 3. Therefore the following command must be sent:
Command: 3S2+3!
Response: 3\0d\0a

This response confirms that the event counter has been successfully set.

3.3.5. Reset Event Counter

- command: aS5!
- response: a\<cr>\<lf>

This command resets the event counter counts to zero.

3.3.6. Set Averaging Parameters

- command: aS6+\<sampling period>+\<number of samples>!
- response: a\<cr>\<lf>

This command sets the parameters used for calculating the average encoder position as per the 'M5' command (see section 3.2.4. Get Average, Max/Min Encoder Position). The sampling period is defined in increments of 100msec and must be

$$1 =< \textbf{sampling period} =< 255$$

Therefore, the range of the *actual sampling period* is 100msec =< actual sampling period =< 25.5 seconds.

The number of samples must be as follows:

$$1 =< \textbf{number of samples} =< 255$$

Note that the parameters "sampling period" and "number of samples" determine the *Response Time* for the 'M5' command.   The *Response Time* is computed from these parameters and displayed in the response to the 'M5' command as required by the SDI-12 protocol (eg. a0101, *Response Time* = 10 seconds).

However, the maximum allowable *Response Time* is **999 seconds.**

NOTE: If the user sets the *Response Time* to a value greater than 999 seconds, the PSE-SDI will not respond to the 'M5' command. The Query Command (see section) may be used to determine the current *Response Time* of the averaging feature as set by the 'S6' command. In the event that it was set greater than 999 seconds the Query Command will display a value of "ERR" for the *Response Time*.

Example:
   The current sensor address is 7 and you wish to set the averaging parameters as follows: actual sampling period of 0.5 seconds and 15 samples. Therefore, the sampling period must be set to 5 (100 msec X 5 = 0.5sec) and the number of samples to 15. Therefore, send the following command:

   Command: 7S6+5+15!
   Response: 7\0d\0a

It's done! All subsequent 'M5' commands (see section 3.2.4 Get Average, Max/Min Encoder Position) will return the average of 15 samples taken over 7.5 seconds.

4. PSE-SDI\D Display Operation

The PSE-SDI\D comprises an 8-digit display and two double-position switches that control the display and setup of parameters. The setup parameters are only accessible however, once the correct password has been entered. The front of the unit appears as in Fig.1.
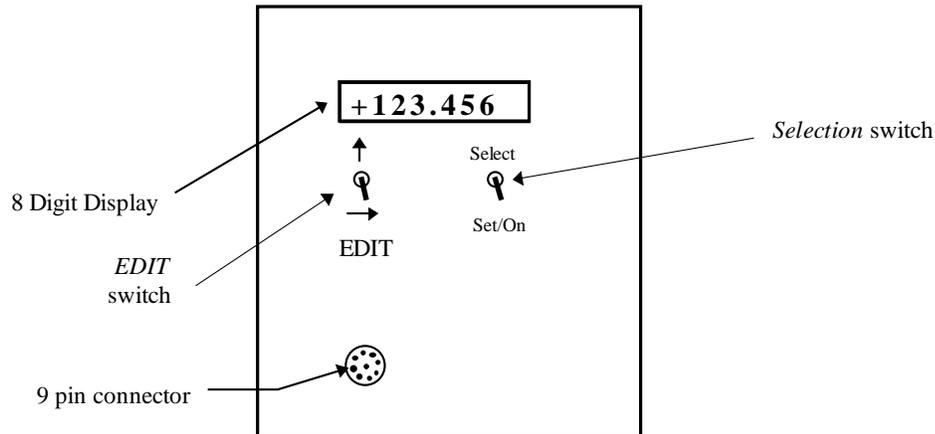
Figure 1. Front view of the PSE-SDI\D.

The four switch positions allow the user to display the current fluid level as well as setup the following parameters: the encoder offset and scale, the node address for SDI-12 communications and the averaging parameters as per section *3.3.6 Set Averaging Parameters.*.

The right switch is used to *select* the parameter to be displayed and/or altered. It is also used as an enter key to *set* the new values of setup parameters, and as an *on* switch for the display. The left switch allows the user to *EDIT* the value displayed at the screen. The lower position of this switch is labeled with a right-arrow and is used to select the digit that is to be edited; the "active" digit is the one flashing on the screen. The upper position, which is labelled with an up-arrow, edits the active digit by scrolling through the available options: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, ., +, -.

Note that when entering values for the offset and scale the decimal point must be entered as these parameters are floating point variables. The "+" or "-" sign must also be entered for these parameters. For instance, a scale of +1.000 may be entered as "+1." but not as "+1", "1." or "1". It is a good practice to review any changes by scrolling down the display using the *set/on* switch and making further alterations is necessary.

The display comprises an auto power-off feature. It switches the display off following an inactive period of approximately 5 minutes in order to save energy. Note that although the PSE-SDI\D consumes as little as 5 mA when the display is off the current consumption is about 90 mA when it is on.

4.1. <u>View the Current Level</u>

To use the display to view the current fluid-level turn it on with *set/On*. The current fluid level appears.

4.2. <u>Accepting/Changing the Password</u>

Set-up the PSE-SDI\D using the display (setup can also be done using the SDI-12 commands described in section 3. SDI-12 AMASSER SE Sensor Commands) and a DCP or portable computer) as follows:

- Switch it on with *Set/On*. The current encoder position, i.e. water level, is displayed.
- Now use *select* until "PASSWORD" appears then use *set/On* ("+000" appears).
- The default password of "+000" is displayed.
- Use *Set/on* to accept the current display as the password (or use the *EDIT* switch to change the display to the correct password if it has been changed). Note that the correct password must be entered to gain access to the setup parameters.
- You have the option of defining a personal password using the *EDIT* switch. When entering the four-character password the following characters are valid: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, ., +, -, <space>. The password can only be viewed or altered from the display and must be entered correctly to view the remaining setup parameters. **To set the password equal to the characters displayed on the screen press the *Set/On* switch.**

Note that the correct password that was entered to gain entry to the setup parameters can be viewed as long as the display has not switched off with the auto power-off feature. Note that if the display does shut off and is turned back on, "PASSWORD" will display the default value, namely "+000", which must be edited once again to obtain access. <u>Never forget your password otherwise you will not be able to change the setup parameters from the display at a later date.</u> In the event that it is forgotten contact AMASS Data Technologies Inc.

4.3. <u>Set the "Scale" and "Offset"</u>

- Turn on the display with *Set/On*.
- Push switch to *Select* until the word 'PASSWORD' appears.
- Push switch to *Set/On*. The default password appears: '+000'.
- Enter the correct password then press *Set/On*. See 4.2.
- Push *Select* until the word "SCALE" or "OFFSET" appears.
- Push *Set/On*. The current value of the parameter appears.
- Make changes with the *EDIT* switch and accept the new value with *Set/on,* OR cancel your changes by pushing *Select*.

4.4. <u>Set the Node Address</u>

- Turn on the display with *Set/On*.
- Push switch to *Select* until the word 'PASSWORD' appears.
- Push switch to *Set/On*. The default password appears: '+000'.
- Enter the correct password then press *Set/On*. See 4.2.
- Push *Select* until "NODE ADR" appears.
- Push *Set/On*. The current node address appears.
- Make changes with the *EDIT* switch and accept the new value with *Set/on,* OR cancel your changes by pushing *Select*.
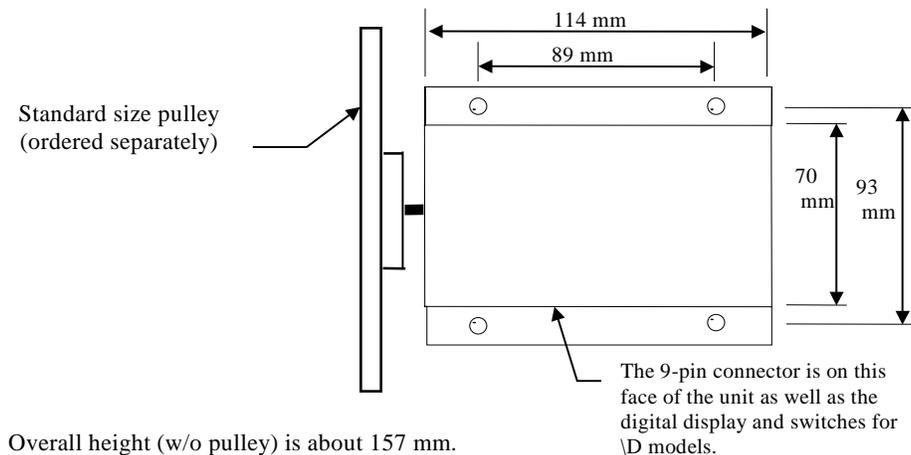
5.   Installation

5.1. Mechanical

All AMASSER Incremental Shaft Encoders may be attached to a flat surface using #10 bolts or screws through the four holes located in the mounting brackets on the PSE-SDI(\D) housing as shown in Figure 2. When installed to measure water level, it may be attached to a horizontal or vertical surface in a gauge house, with the shaft extending horizontally over the stilling well. A pulley (not included) is mounted to the unit by means of the Delrin shaft hub (see Figure 3A). Delrin is a non-conductor which provides electrical isolation between the sensor and the water thus bestowing lightning protection to the unit.

AMASS Data Technologies provides industry-standard *pulleys* and *graduated punched tapes* for this purpose.   For more information on our pulleys and tapes contact us at sales@amassdata.com or call at (819) 827-0077.

Standard size pulley (ordered separately)

114 mm

89 mm

70 mm

93 mm

The 9-pin connector is on this face of the unit as well as the digital display and switches for \D models.

Overall height (w/o pulley) is about 157 mm.

Figure 2. Top view of PSE-SDI(\D) with mounting brackets installed.

The sensor may be installed in any orientation that a particular application may require. Weights or other mechanical loads at right angles to the shaft centre line should not exceed 10 lb (4.5 kg). Larger loads will distort the bearings, increase the starting torque, and decrease the bearing life.

5.1.1. Mounting a Pulley

For units purchased after January 1, 2008 the pulley is mounted to the hub by means of a ¼"-28 X 3/8" nylon machine screw.   Install the pulley to the hub as follows:
- o   Put the pulley onto the hub as shown in Figure 3B.
- o   Put large nylon washer onto the hub as shown in Figure 3C.
- o   Install the ¼"-28 X 3/8" nylon machine screw with the stainless steel flat and lock washers (Figure 3D).

NOTE: Tighten the nylon machine screw to 5kg-cm (about 6ozf-ft) of torque.   Excessive torque will strip the threads.

| A | B | C | D |
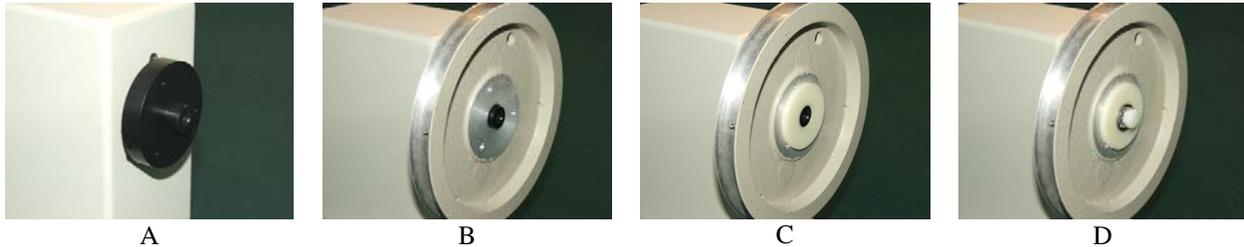
Figure 3. Photos of mounting a pulley to the hub.

5.2. Electrical

The Encoder is internally protected against transient voltages and lightning surges on the signal input lines. However,

 IT IS ESSENTIAL TO PROVIDE PRIMARY EXTERNAL LIGHTNING PROTECTION.

The 9 V battery backup is only enabled when the cable is secured to the unit. Therefore if the connector remains mounted to the unit the 9V battery will provide backup if the power supply fails or becomes disconnected (at the power supply, not the PSE-SDI(\D)). If the connector is removed at the PSE-SDI(\D) however the buffers are cleared and the unit must be reinitialized using the *Setup sub-menu.* This is because the connector closes the backup circuit through pins 7 and 9 (see *Connectors*) so that if it is not mounted the 9V battery-backup facility becomes disabled.

Note that the backup is provided regardless of whether the cable is connected to a source or not as long as the connector is mounted to the PSE-SDI(\D). The open circuit that results when the cable is not connected means that the PSE-SDI(\D) can be stored without depleting the 9 V battery.

5.3. Connectors

1   9 pin AMP CPC Connector

Connections are as follows:

PIN	SIGNAL	Cable Color
1	+ 12 Vin	Red
2	none	Blue
3	Ground	Black
4	SDI-12 DATA*	White
5	Event Counter	Green
6	Ground	none
7	Ground	Jumper across 7and 9
8	SDI-12 DATA	Brown
9	Neg. terminal of +9 V battery	Jumper across 7and 9

5.4. Standard SDI-12 / RS485-based SDI-12

The PSE-SDI (rev D and later) may be configured for standard SDI-12 or RS485-based SDI-12. This configuration is simply a jumper selection. Standard SDI-12 only supports distances up to 200 feet between the sensor and logger according to section 1.0 of the Specification (version 1.3) whereas **RS485-based SDI-12 allows distances up to 4000 feet between the sensor and the logger**. Note that once configured to RS485-based SDI-12, your PSE-SDI is no longer compatible with loggers which do not support this capability.   Consult the documentation of the logger to which the PSE-SDI is to be connected. Note that the AMASSER PDAS-II loggers allow RS485-based SDI-12 on channel B.

Figure 4 shows the location of the jumper blocks. The block labeled 'HC' is for standard SDI-12 where the other (labeled '485') is for RS485-based SDI-12.
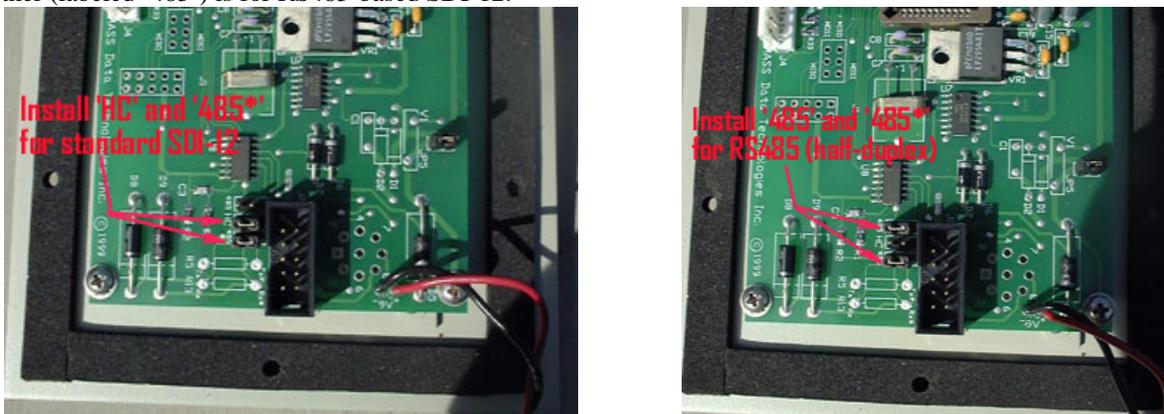

Figure 4. Proper jumper configurations for standard SDI-12 (HCMOS) versus RS485.

6. <u>Specifications</u>

Processor : Atmel 89S8252 @ 3.6864 MHz.
Word Size : 8 bit data - 8 bit instruction
Memory : 89S8252, 256 bytes RAM
EEPROM 2 kbytes

<u>Shaft Encoder</u>
K-Model
Sensor type - two channel optical incremental
encoder 96 x 4 counts per revolution
Resolution - 384 counts per revolution;
software conversion to engineering units
provided in firmware. (Units per revolution)

<u>Range</u>
+/- 32.0 m with .375 m circ. Pulley (avail. sep.)
+/- 85.3 ft with 1.00 ft circumference pulley

<u>Max. Response Speed</u>
2.5 rev/sec.

<u>Output</u>
SDI-12 protocol :
- ASCII accumulated level: Instantaneous or Averaged

<u>Event Counter Input</u>
5 kHz max. (Pulse mode)
100 Hz max. (Switch Closure mode)

<u>Connector</u>
9 pin AMP CPC Connector
Current Carrying Capability - 1.5 Amp rating
Dielectric Withstanding Voltage >1500V

<u>Power Supply</u>
+10.5 to 15 VDC input for external battery,
charger or power supply

<u>Power Consumption</u>
< 5 mA quiescent current

maximum current : < 30 mA (with display off)

<u>Battery Backup</u>
9 V 565 mAHr alkaline battery backup
(Only if 9 pin connector is mounted)

Mechanical Interface
<u>Threaded shaft</u>
1/4 x 32 thread plus clamp assembly
#303 stainless
<u>Maximum safe load</u>
10 lb 4.5 kg.
<u>Starting Torque</u>
0.65 inch-oz (47 cm-g) max.

Physical Characteristics
Height : 165.0 mm. (6.5 in.)
Width : 114.0 mm. (4.5 in.)
Depth : 70.0 mm. (2.75 in.)
Weight : 1.35 Kg (3.0 lb.)
Mounting brackets: use four #10 bolts or screws.

Environmental Characteristics
Operating : -40 to +55 C
Storage : -60 to +100C
Humidity : <= 100% non-condensing

The above information is believed to be true at the time of printing. AMASS Data Technologies Inc. reserves the right to modify specifications without notice. All trademarks are owned by their respective companies.

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APPENDIX A: PSE-SDI(\D) SDI-12 Command Set: Quick reference

Retrieve Data Commands

1. Get encoder value in scaled units
   - command: aM!, aM0!, aC! or aC0!
   - response: a0001<cr><lf> data buf: <encoder value>

2. Start verification command
   - command: aV! or aV0!
   - response: a+<data buffer 1>+<data buffer 2>+<data buffer 3><cr><lf>

3. Get event counter value
   - command: aM3! or aC3!
   - response: a0001<cr><lf> data buf: <event counts>

4. Get average, Max/Min encoder position
   - command: aM5! or aC5!
   - response: attt1<cr><lf> data buf <average position>, ttt=(actual sampling period X # of samples) + 1 sec

5. Return data buffer
   - command: aD! or aD0!   Response: a<data buffer><cr><lf>

6. Return identification string
   - command: aI!   response: a<identificationstring><cr><lf>

7. Acknowledge active command
   - command: a!   response: a<cr><lf>

8. Address query command
   - command: ?!   Response: a<cr><lf>

9. Change SDI device (node) address
   - command: aA<new address>!   Response: <new address><cr><lf>

10. Query Command
    - command: aQ0! or aQ1! or aQ2! or aQ3! etc…   Response: a<information string><cr><lf>

11. Read Value of Set-up Parameter
    - command: aS0?!, aS1?!, aS6?!   Response: a<data buffer><cr><lf>

Set Commands

1. Set encoder offset
   - command: aS0<offset>!   Response: a<cr><lf>

2. Set encoder scale (units per revolution)
   - command: aS1<scale>!   Response: a<cr><lf>

3. Set Scale of the Event Counter
   - command: aS3+<scale>!   Response: a<cr><lf>

4. Set Mode of Event Counter
   - command: aS2+<mode>!   See App. B for modes
   - Response: a<cr><lf>

5. Reset Event Counter
   - command: aS5!   Response: a<cr><lf>

6. Set averaging parameters
   - command: aS6+<sampling period>+<number of samples>!
   - response: a<cr><lf>

APPENDIX B: Modes of the Event Counter

The event counter is configurable to your application using the 'S2' command as per section 3.3.4 Set *Mode* of Event Counter. The modes are listed here for your convenience. Note that the default mode is '0'.

Mode Code	**Read/Reset** versus **Overflow**	**Pulse** versus **Switch Closure**
0	Overflow (0)	Switch Closure (0)
1	Overflow (0)	Pulse (1)
2	Read/Reset (1)	Switch Closure (0)
3	Read/Reset (1)	Pulse (1)

R/R: stands for 'Read/Reset'. In this mode the event counter is cleared upon sampling. If the count exceeds the 16-bit maximum (65535) prior to sampling it overflows to 0 and starts over.

OVERFLOW: Otherwise known as 'roll-over', in this mode the event counter is cumulative. When the count exceeds the 16-bit maximum (65535) it overflows to 0 and starts over.

PULSE: In this mode the event counters are set to count pulses. The maximum frequency is 5 kHz.

SWITCH CLOSURE: In this mode the event counters are set to count switch closures and accommodate moderately noisy signals which are typical of switch closures. The minimal period of the closure is 20 msec.