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TECHNOLOGIES INC.

PSE\RTU & PRTU
Quadrature Shaft Encoder with ModBUS Protocol Interface
including the following options:
\D, \4-20

User Reference Manual

Firmware Revision # 141 and later

Updated: Jan. 22nd, 2009

http://www.amassdata.com

Clockwise rotation of the pulley represents rising water levels when the scale is positive, otherwise the scale must be set negative.

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Quadrature Shaft Encoder with ModBUS RTU Protocol Interface
## PRTU
Pliant Remote Terminal Unit
Pliant Technology Specialists

Pliant: readily yielding to influence

1.   PSE/RTU Shaft Encoder

The PSE/RTU 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.   The PSE/RTU accumulates position data up to 2500 times per second to ensure accurate tracking of the shaft.

The PSE/RTU provides its sensed data to the Data Collection Platform (DCP), personal computer, programmable controller or other host device directly by means of the ModBUS RTU Protocol, or indirectly by means of a PRTU Remote Terminal Unit (See section 1.2). The standard PSE/RTU provides the ModBUS RTU communications by means of an RS485 driver thus allowing support up to 4000 feet on two twisted pairs. A built-in leased-line or dial-up modem (options /MDMLL and /MDM only), in conjunction with the PRTU Remote Terminal Unit (section 1.2), allow communication over any distance covered by a telephone line.   Another possibility is to interface the PSE/RTU directly to a host requiring a 4-20mA input (option **4-20**). These communication options are depicted below (refer to section 4.2 Electrical for proper connections).
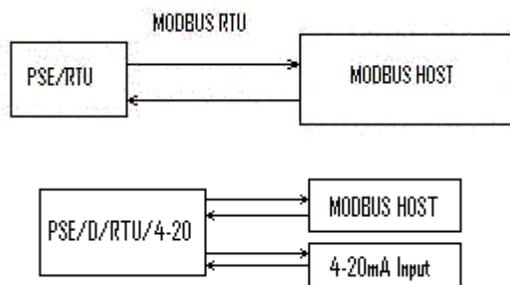
1.1. PSE/RTU Standard Features

The resolution of the encoder is 1/400th of a revolution (standard); when used with a stream stage pulley with a 375 mm circumference, the resolution of the system is 0.94 mm. When used with a 12.00 inch-circumference pulley, the resolution of the system is 0.03 inches or 0.0025 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/RTU firmware provides a pulsed LED driver and signal transition detector that provides the 4x quadrature decoder function.

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 following set-up data: the encoder "SCALE" and "H2O LEVEL", the "CL ZERO" and "CL SPAN" (**4-20** models only) as well as the "Alrm-Upr" and "Alrm-Lwr" (/SW option only).   A 9 V alkaline battery provides backup (a total of approximately 70 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 aluminium case, and may be installed in exposed locations. It is tested to operate from -40C to +55C, and up to 100% relative humidity.

1.2. PRTU: Remote Terminal Unit

The PRTU is a remote terminal unit which polls the PSE/RTU at regular intervals, displays the realtime reading on a LED display, and presents the data to the HOST machine via MODBUS RTU, or 4-20mA ("/4-20" option only). Various configurations are depicted below:
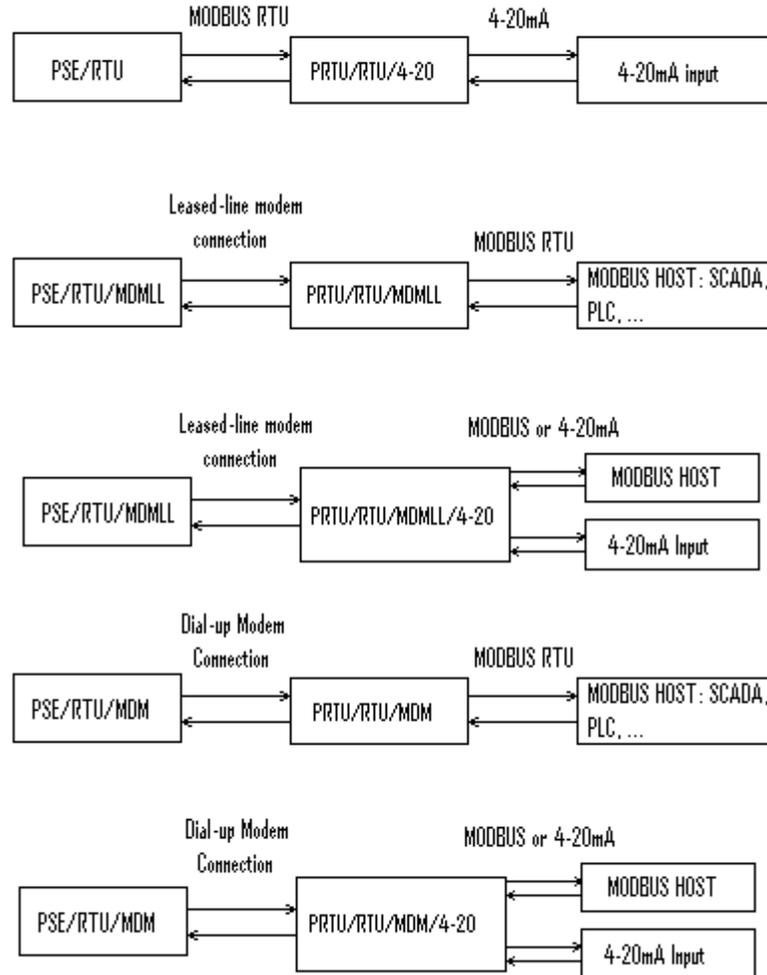
The polling rate of the PRTU/RTUMDMLL (leased-line modem) is once per second. The implementation of the /MDM (dial-up) modem option depends on the exact requirements of the application.

1.3. Options

Here are the options of the PSE/RTU:

The **\4-20** option: The '\4-20' option is a 4-20 mA module which provides a standard current loop as a means of relaying the acquired data to the host in applications requiring an analog interface.

The **\D** option: This option provides an 8-digit display and two operator switches that allow the user to view data as well as set parameters (*H2O Level, Scale, CL Offset, CL Span …*).

The **\SW** option (standard since July 1, 2003) : This option provides a built-in reed relay with closure controlled by user-definable water levels. The \SW units allow the user to define an "Upper" and "Lower" alarm point, the difference between the two constituting the hysteresis of the system. The \SW relay is typically used to operate a relay of greater current carrying capacity. The "Upper" and "Lower" alarm points usually represent critical levels

(eg. flood, drought, …). Note that the exact implementation of the option '/SW' varies depending on customer requirements. However, most incorporate two switches points, each with its own hysteresis. See section 4.3.3 Relay Output.

The **\MDM** and **\MDM\V** options: Built-in PMDM environmental modem (See PMDM user manual). The standard PSE/RTU uses an RS485 output for driving the MODBUS RTU protocol. Alternatively, the \PMDM option provides modem communications whereas the \PMDM\V provides both modem and voice-modem communications. The **\PMDMLL** option denotes a leased-line modem.

The **/ALI** and **/ALO** option: At the time of printing this option was only available for units equipped with a modem (/MDM). **"/ALI"** provides detection and broadcast of an external switch closure connected to the event counter input. The occurrence of a switch closure, which can be used for detection of power-supply failures or intruder alerts, is relayed to the host **PRTU** unit via the modem interface. See section 2.1.7.
　　　　"/ALO" is an option that is available to the **PRTU** display devices and corresponds to the "/ALI" option for the **PSE/RTU**. "/ALO" provides an internal relay in the PRTU which is controlled by detection of a remote switch closure as communicated by the PSE/RTU device. Refer to section 2.1.7.

1.4. <u>Quadrature Encoder -Principle of Operation</u>

　　　　The PSE/RTU is provided with an on-board 89S8252 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 MODBUS RTU 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), or 400 (Model C encoder).

　　　　Communication with an external controller or computer is according to the MODBUS RTU protocol. The output will be a decimal value in the range +/-999.999 units. The encoder's *Scale* and *H2O Level* are set using MODBUS RTU commands. As mentioned, the value of *Scale* must be equal to the circumference of the wheel whereas *H2O Level* is set equal to the initial fluid level. For instance, if you want the PSE/RTU to track the stage in meters above sea level, you would measure your stage at set-up time and enter it in metres above sea level. If you measure it as being 101.225, you would simply enter 101.225 as your *H2O Level* and the unit would now track your stage in meters above sea level.

2.　　**ModBUS RTU Interface for the PSE/RTU**

　　　　The PSE/RTU is a device that uses the MODBUS RTU Protocol as an interface to your PLC or other host, and as such, follows the guidelines set out in that protocol. The MODBUS RTU register assignments are shown below. <u>Note that the MODBUS RTU register assignments for the **PRTU/RTU** Remote Terminal Unit are depicted in an ADDENDUM</u>.

2.1. <u>Register Assignments</u>

2.1.1. <u>Encoder Position: Registers 1 & 2</u>

These registers form a 4-byte binary representation of the encoder position in engineering units. The shaft position is converted to engineering units using the SCALE and OFFSET registers. The units are consistent with the SCALE and OFFSET and are presented with three decimal places.

NOTE: All values that represent engineering units in the PSE shaft encoder, that is, SCALE, OFFSET and CURRENT SHAFT POSITION, are stored to three decimal places. Therefore, a CURRENT SHAFT

POSITION of +11.123 would be read as '00002B73' (hex) (11123 decimal) using the MODBUS RTU protocol.

Example: Read the current shaft position (water level) in engineering units of the PSE/RTU at slave address 160 (A0 hex). Note that Register 1 and 2 are addressed as '0' and '1' according to MODBUS protocol.

Field name	Example query		Field name	Example Response (hex)
Slave address	a0		Slave address	a0
Function	03		Function	03
Starting address Hi	00		Byte Count	04
Starting address Lo	00		Data Hi	2B
Number of points Hi	00		Data Lo	73
Number of points Lo	02		Data Hi	00
Error check (CRC)	--		Data Lo	00
			Error check (CRC)	--

This response indicates that the current water level is '00002B73' hex, or 11123 decimal. Always interpret the PSE/RTU registers using three decimal places, therefore, 11123 is +11.123.

NOTE: The PSE/RTU responds with the Least Significant Word followed by the Most Significant Word for values stored in two registers.

2.1.2. Encoder 16-bit Value/ Comm Status: Register 3

This register contains the encoder value in counts. The PSE/RTU uses a 16-bit counter and optical encoder for tracking the position of the shaft. This register is automatically set to zero when a value is written to the Shaft Encoder Offset register. Therefore, the PSE/RTU tracks the shaft position up to 32767 counts above and below the initial water level stored in registers 5 and 6. The contents of Register 3 is converted to engineering units using the SCALE and OFFSET, then stored in registers 1 and 2 (see above).

Example: Read the 16-bit encoder of the PSE/RTU at slave address 160 (A0 hex). Note that Register 3 is addressed as '2' according to MODBUS protocol.

Field name	Example query		Field name	Example Response (hex)
Slave address	a0		Slave address	a0
Function	03		Function	03
Starting address Hi	00		Byte Count	02
Starting address Lo	02		Data Hi	0B
Number of points Hi	00		Data Lo	B8
Number of points Lo	01		Error check (CRC)	--
Error check (CRC)	--			

This example response indicates that the 16-bit encoder value is currently 0BB8 (hex), or 3000 decimal. Most PSE/RTU units use a C series encoder which provides 400 counts per revolution. Therefore, with a SCALE of, say, 1 foot per revolution, the resolution would be 1/400= 0.0025 feet. In this instance 3000 counts would represent 3000 X 0.0025 = 7.500 feet above the initial water level.

NOTE: The type of optical encoder in use in any given sensor appears in its serial number as a letter'C' or 'K'.
- **K series = 384 counts per revolution**
- **C series = 400 counts per revolution**

To confirm the type, the user can open the enclosure and look for a 'C' or 'K' on the optical encoder itself.

2.1.3. Encoder SCALE: Register 4

- *Default Scale = +0.375*

The "SCALE" represents the circumference of the float pulley mounted to the shaft. The default is '+0.375' for standard pulleys that are 0.375 metres in circumference. This register can be read or written using the MODBUS RTU interface or the switches and LED display for models with option '/D' (See 3). If a pulley of 1 foot in circumference is mounted to the shaft the 'SCALE' would be set to '+1.000' or '-1.000' for an output of water level in feet.
In addition to the size of the pulley, when initializing the 'SCALE' the user must be aware of the DIRECTION OF SHAFT ROTATION with respect to water levels.

Clockwise rotation of the pulley represents rising water levels when the SCALE is positive, otherwise the SCALE must be set negative.

NOTE: All values that represent engineering units in the PSE shaft encoder, that is, SCALE, OFFSET and CURRENT SHAFT POSITION, are stored to three decimal places. Therefore, a SCALE of 1 foot would be written as '03E8' (hex) (1000 decimal) using the MODBUS RTU protocol.

Example: Read the "SCALE" of the PSERTU at address a0(hex). Note that Register 4 is addressed as '3' according to MODBUS protocol.

Field name	Example Query		Field name	Example Response (hex)
Slave address	a0		Slave address	a0
Function	03		Function	03
Starting address Hi	00		Byte Count	02
Starting address Lo	03		Data Hi	01
Number of points Hi	00		Data Lo	77
Number of points Lo	01		Error check (CRC)	--
Error check (CRC)	--			

The example response is 177 (hex) , that is, 375 decimal. The PSE/RTU uses three decimal places therefore '375' is interpreted as '0.375'.

2.1.4. Shaft Encoder Offset: Register 5 & 6

- *Default Offset = +0.000*

The Shaft Encoder Offset is, in fact, the initial water level. A secondary means of measuring the water level at the time of installation must be employed to obtain an initial reading and set the Shaft Encoder Offset. Two registers are used to store this value, that is, 16 bits.

NOTE: All values that represent engineering units in the PSE shaft encoder, that is, SCALE, OFFSET and CURRENT SHAFT POSITION, are stored to three decimal places. Therefore, an OFFSET of +12.000 would be written/read as '00002EE0' (hex) (12000 decimal) using the MODBUS RTU protocol.

<u>Example</u>: Set the initial water level (Shaft Encoder Offset) of the PSE/RTU at address 160 (A0 hex) to +12.000. Note that Register 5 and 6 are addressed as '4' and '5' according to MODBUS protocol.

Field name	Example query		Field name	Example Response (hex)
Slave address	a0		Slave address	a0
Function	10		Function	10
Starting address Hi	00		Starting address Hi	00
Starting address Lo	04		Starting address Lo	04
Number of registers Hi	00		Number of registers Hi	00
Number of registers Lo	02		Number of registers Lo	02
Byte count	04		Error check (CRC)	--
Data Hi	2E			
Data Lo	E0			
Data Hi	00			
Data Lo	00			
Error check (CRC)	--			

The response indicates that 2 registers, beginning with register 5 (address 4), were preset.

NOTE: The user cannot preset multiple values of the PSE/RTU at once otherwise an exception code will result. For instance, register 4 ("SCALE"), 5 and 6 cannot be written simultaneously. Each must be written individually.

2.1.5. MODBus RTU Address: Register 15

- *Default MODBus RTU Address = 160 (or A0 hex)*

This register contains the communications address of the PSE/RTU. All the read and write functions that occur in the MODBus protocol contain the slave device address to which the command is destined.

VALID ADDRESSES FOR THE PSE/RTU: **1 to 247 (1 to F7 hex)**

2.1.6. Relay Output

Since July 1, 2003 all PSE/RTU are equipped with a software-controlled relay output. This is provided by means of a reed relay which is rated up to 2A and is typically used to control a relay of higher current carrying

capability. The levels for which the relay closes and opens are user-configurable and usually represent alarm conditions such as drought and flood conditions.

2.1.6.1. <u>Upper Alarm Level: Register 7 & 8</u>

- *Default Upper Alarm Level = +10.000*

The UPPER ALARM LEVEL is the value at which the internal relay closes as the level is <u>rising</u>, that is, it represents a flood condition. The relay reopens when the CURRENT SHAFT POSITION <u>drops</u> below the UPPER ALARM RESET (next section).

NOTE: All values that represent engineering units in the PSE shaft encoder are stored to three decimal places. Therefore, an UPPER ALARM LEVEL of +29.211 would be read as '0000721B' (hex) (29211 decimal) using the MODBUS RTU protocol.

<u>Example:</u> Set UPPER ALARM LEVEL of the PSE/RTU at address 160 (A0 he)x to +29.211.   Note that Register 7 and 8 are addressed as '6' and '7' according to MODBUS protocol.

Field name	Example query		Field name	Example Response (hex)
Slave address	A0		Slave address	A0
Function	10		Function	10
Starting address Hi	00		Starting address Hi	00
Starting address Lo	06		Starting address Lo	06
Number of registers Hi	00		Number of registers Hi	00
Number of registers Lo	02		Number of registers Lo	02
Byte count	04		Error check (CRC)	--
Data Hi	72			
Data Lo	1B			
Data Hi	00			
Data Lo	00			
Error check (CRC)	--			

2.1.6.2. <u>Upper Alarm RESET: Register 9 & 10</u>

- *Default Lower Alarm Level = +9.900*

The UPPER ALARM RESET is the value at which the internal relay (/SW models only for models prior to July 1, 2003)) reopens after having been triggered by the UPPER ALARM LEVEL.   Therefore,

$$\text{Hysteresis } = \text{ (U. A. LEVEL } - \text{ U. A. RESET)}$$

NOTE: The UPPER ALARM RESET must be set **<u>below</u>** the UPPER ALARM LEVEL

2.1.6.3.   Lower Alarm Level: Register 11 & 12

- *Default Lower Alarm Level = +5.900*

The LOWER ALARM LEVEL is the value at which the internal relay closes as the level is <u>dropping</u>, that is, it represents a drought condition. The relay reopens when the CURRENT SHAFT POSITION <u>rises</u> above the LOWER ALARM RESET (next section).

NOTE: All values that represent engineering units in the PSE/RTU shaft encoder are stored to three decimal places. Therefore, a LOWER ALARM LEVEL of +3.666 would be read as '00000E52' (hex) (3666 decimal) using the MODBUS RTU protocol.

<u>Example:</u> Set LOWER ALARM LEVEL of the PSE/RTU at address 160 (A0 hex) to +3.666.   Note that Register 11 and 12 are addressed as '10' and '11' according to MODBUS protocol.

Field name	Example query		Field name	Example Response (hex)
Slave address	A0		Slave address	A0
Function	10		Function	10
Starting address Hi	00		Starting address Hi	00
Starting address Lo	0A		Starting address Lo	0A
Number of registers Hi	00		Number of registers Hi	00
Number of registers Lo	02		Number of registers Lo	02
Byte count	04		Error check (CRC)	--
Data Hi	0E			
Data Lo	52			
Data Hi	00			
Data Lo	00			
Error check (CRC)	--			

2.1.6.4.   Register 13 & 14: Lower Alarm RESET

- *Default Lower Alarm Reset = +6.000*

The LOWER ALARM RESET is the value at which the internal relay (/SW models only for models prior to July 1, 2003) reopens after having been triggered by the LOWER ALARM LEVEL.   Therefore,

$$\text{Hysteresis} \ = \ (\text{L. A. RESET} \ - \ \text{L. A. LEVEL})$$

NOTE: The LOWER ALARM RESET must be set <u>above</u> the LOWER ALARM LEVEL.

2.1.7. "ALI" Option

(After May28, 2003)

At the time of printing, the /ALI option is only available to PSE/RTU units that are equipped with a modem. (options "/MDMLL" and "/MDM").

This option, which stands for ALarm Input, provides detection and immediate broadcast of an external switch closure connected to the event counter input (see 4.3.1).   The switch closure causes the PSE/RTU to alert the host PRTU (Remote Terminal Unit) via the modem interface.

The occurrence of a switch closure is relayed to the host device by altering the value for the current shaft position (registers 1 and 2) as follows:

Table 1. Substitution of characters for alerting the PRTU of a switch closure (/ALI only).

Switch Open	Switch Closed
+	@
-	~

The PRTU stores the most recent water level reading in registers 1 and 2. The presence of the "@" or "~" characters in these registers alerts the host MODBus device that a remote switch closure has occurred.

The "@" or "~" character disappears the moment the external switch opens.

The applications of this feature are numerous. For instance, it can be used for detection of an intruder into the shelter where the equipment is installed, or, with proper use of an external relay, it has been used for detecting of a power supply failure.

2.2. <u>function codes</u>

2.2.1. <u>03: read holding register</u>

Function code '03' is used for reading registers in the PSE/RTU. Several examples are provided in the previous sections.

2.2.2. <u>16 (10 hex): preset multiple registers</u>

Function code '10' (hex) is used for writing registers in the PSE/RTU. See section 2.1.4 for an example.

NOTE: The user cannot write multiple values of the PSE/RTU at once otherwise an exception code will result. For instance, register 4 ("SCALE"), 5 and 6 cannot be written simultaneously.   However, registers 5 and 6 must be written with a single command because they represent one value, the OFFSET.

2.2.3. <u>17 (11 hex): report slave id</u>

Returns a description of the PSE/RTU at the requested address.

<u>Example:</u> Request an identification of the PSE/RTU at address 160.

Field name	Example (hex)
Slave address	a0
Function code	11
Error Check	--

The response would be an identification string from the PSE/RTU.

3. Display Operation: \D Option

The \D option provides 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.
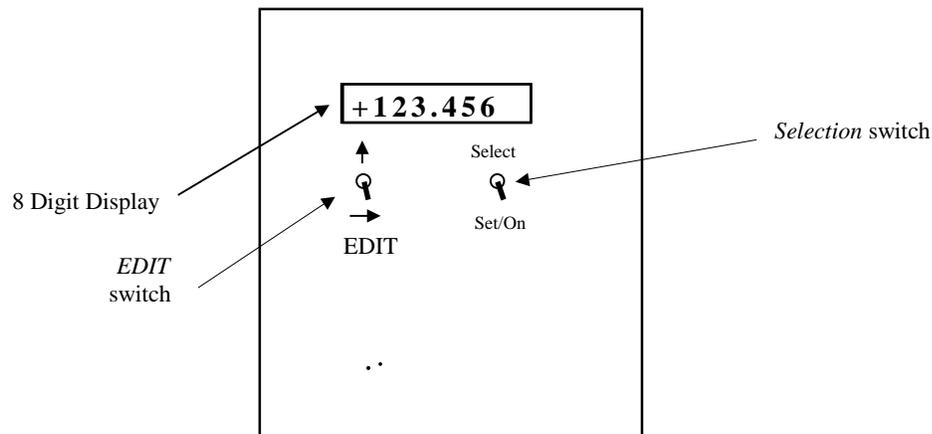

Figure 1 Front view of the PSE/RTU\D.

The four switch positions allow the user to display the current fluid level as well as setup the following parameters: the encoder *H2O Level* and *Scale*, the *CL ZERO* and *CL SPAN* (\4-20 option only), the *ALARM-UPR* and *ALARM-LWR* (/SW option only) and the node address for MODBUS RTU communications.

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, ., +, -.

In short, the value of a parameter is displayed and entered using *set/on*. If the value that is displayed is correct it may be left unaltered by simply reentering it using *set/on*. On the other hand, any changes made to a value that has not yet been saved may be disregarded by using *select*.

3.1. Displaying the Fluid Level

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

3.2. Accepting/Changing the Password

Set-up of the PSE/D/RTUusing the display is password-protected (setup can also be done using the MODBUS RTU commands described in section 2). Begin by switching 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" can now be edited to your own using the *EDIT* switch if you desire password-protection. 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* switch,** otherwise press *Select*.

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 (see below). If the display does shut off however, and is turned back on "PASSWORD" will display the default value, namely "+000", which must be edited once again to obtain access. Never forget your password otherwise you will not be able to change the setup parameters from the display at a later date. In the event that it is forgotten contact AMASS Data Technologies Inc at amassinf@amassdata.com.

3.3. Setting the "H$_2$O LEVEL"

This is equivalent to writing to registers 5 and 6.

Begin by accepting the password as described above. Use *select* until the word "*H2O Level*" appears. Press the *set/On* switch. Use the *Edit* switch to set the display to the current fluid level, then use *set/On* to enter this value.

NOTE that when entering values for the "*H2O Level*" 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". Use *set/on* repetitively to review the list of parameters and their respective values.

3.4. Setting the "wl SCALE"

This is equivalent to writing to register 4.

The parameter "**wl SCALE**" must be set equal to the circumference of the pulley mounted on the shaft encoder. Most standard pulleys are either 0.375metres or 1 ft in circumference. The default *scale* of the PSE shaft encoders is +0.375.
Begin by accepting the password as described above. Use *select* until the word *scale* appears. Press the *set/On* switch. Use the *Edit* switch to set the display equal to the circumference of the pulley mounted on the shaft then use *set/On* to enter this value.

3.5. Setting the Node Address

This is equivalent to writing to register15.

The PSE/D/RTU is a MODBUS RTU device. MODBUS RTU is a multi-drop protocol that allows up to 247 units on the same bus by using a node-addressing scheme. Extensive documentation of the MODBus protocol can be found on-line at http://www.modicon.com/techpubs.
The node address by which MODBUS RTU communication takes place is among the parameters that may be set on the display. This is done in the same manner as with the other parameters: *select* the parameter to be edited, i.e. "**Node Adr**", use *set/on* to view its current value, use the *EDIT* switch as required, then enter the value using *set/on*. Given that 247 MODBUS RTU devices may be supported on a given network, the node addresses are numbered from 1 to 247 decimal (1 to F7 hex). Note that the display shows the Node Address in decimal representation.

The default MODBUS slave address for the PSE/RTU is A0 hex (160 decimal).

3.6. Setting the "Alrm-Upr"

This is equivalent to writing to registers 7 and 8..
"Alrm-Upr" corresponds to the "UPPER ALARM LEVEL" (see section 2.1.6.1), that is, a flood warning condition. This represents the threshold at which the relay **CLOSES** as the water level is INCREASING (see

Figure 2 below).   Begin by accepting the password as described above (sect. 3.2).   Use *select* until the word **"Alrm-Upr"** appears. Press the *set/On* switch. Use the *Edit* switch to set the display equal to the desired value for switch closure, then use *set/On* to enter this value.

NOTE that when entering values for the **"Alrm-Upr"** the decimal point must be present as these parameters are floating point variables. The "+" or "-" sign must also be entered for these parameters.   For instance, an "Alrm-Upr" of +10.000 may be entered as "+10." but not as "+10", "10." or "10". Use *set/on* repeatedly to review the list of parameters and their respective values.
*The default value for "**Alrm-Upr**" is +10.000.*

3.7. <u>Setting the "aUpr-Rst"</u>

This is equivalent to writing to registers 9 and 10.

"aUpr-Rst" corresponds to the "UPPER ALARM RESET" (See section 2.1.6.2).   This represents the value at which the relay **<u>reopens</u>** after being closed by the "Alrm-Upr" value (i.e.UPPER ALARM LEVEL) (see Figure 2 below).

> **NOTE: "AL-UP-RT" must be set <u>below</u> the "AL-UPR".**

Begin by accepting the password as described above (sect. 3.2).   Use *select* until the word **"aUpr-Rst"** appears. Press the *set/On* switch. Use the *Edit* switch to set the display equal to the desired value for switch closure, then use *set/On* to enter this value.
The default value for "aUpr-Rst" is +9.900.

3.8. <u>Setting the "Alrm-Lwr"</u>

This is equivalent to writing to registers 11 and 12.
"Alrm-Lwr" corresponds to the "LOWER ALARM LEVEL" (see section 2.1.6.3), that is, a drought warning condition. This represents the threshold at which the relay **<u>CLOSES</u>** as the water level is DECREASING (see Figure 2 below).   Begin by accepting the password as described above (sect. 3.2).   Use *select* until the word **"Alrm-Lwr"** appears. Press the *set/On* switch. Use the *Edit* switch to set the display equal to the desired value for switch closure, then use *set/On* to enter this value.
*The default value for "**Alrm-Lwr**" is +5.900.*

3.9. <u>Setting the "aLwr-Rst"</u>

This is equivalent to writing to registers 13 and 14.

"aLwr-Rst" corresponds to the "LOWER ALARM RESET" (See section 2.1.6.4).   This represents the value at which the relay **<u>reopens</u>** after being closed by the ALRM-LWR value (i.e.LOWER ALARM LEVEL (see Figure 2 below).

> **NOTE: "aLwr-Rst" must be set <u>above</u> the "Alrm-Lwr".**

Begin by accepting the password as described above (sect. 3.2).   Use *select* until the word **"Alwr-Rst"** appears. Press the *set/On* switch. Use the *Edit* switch to set the display equal to the desired value for switch closure, then use *set/On* to enter this value.
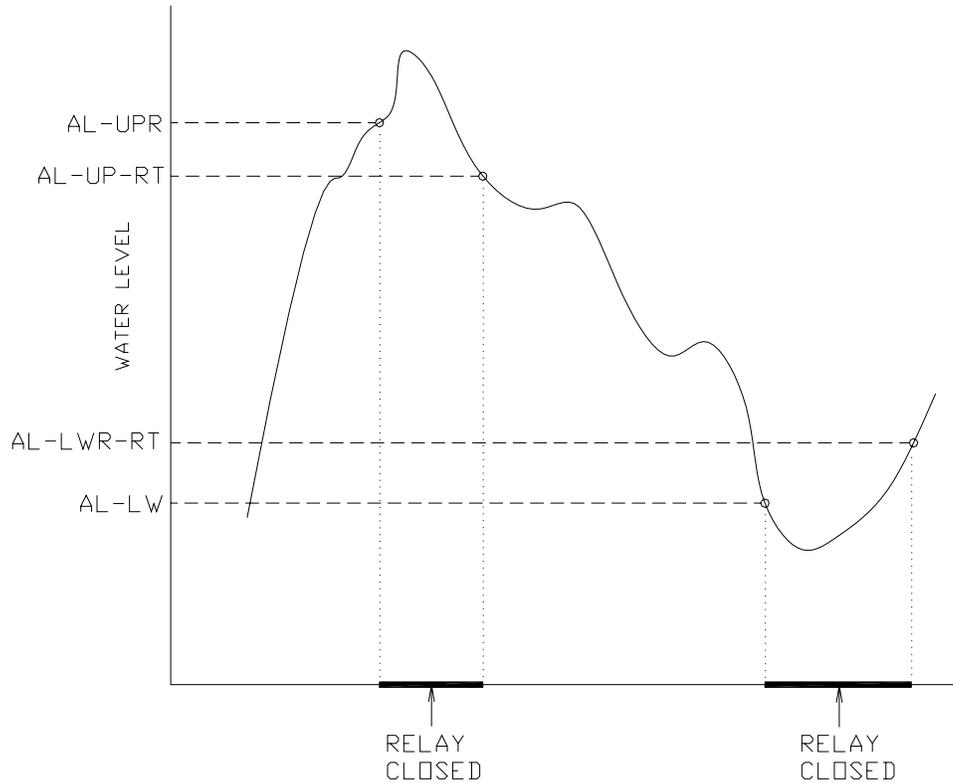*The default value for "**aLwr-Rst**" is +6.000.*

Figure 2. Explanation of relay trigger points for models with an internal relay.

3.10. Setting the "CL Zero" (/4-20 only)

As explained in APPENDIX B, the parameter **"CL Zero"** ('cl' stands for current loop) must be set equal to the minimum anticipated water level, that is, the level for which the PSE/RTU/4-20 will output 4mA.

Begin by accepting the password as described above. Use *select* until the word '**CL Zero"** appears. Press the *set/On* switch. Use the *Edit* switch to set the display to the proper value as described in APPENDIX B, then use *set/On* to enter this value.

NOTE that when entering values for the **"CL Zero"** the decimal point must be present as these parameters are floating point variables. The "+" or "-" sign must also be entered for these parameters. For instance, a value of +1.000 may be entered as "+1." but not as "+1", "1." or "1". Use *set/on* repetitively to review the list of parameters and their respective values.

The default value for "CL Zero" is +6.000.

3.11. <u>Setting the "CL SPAN" (/4-20 only)</u>

As explained in APPENDIX B, the parameter **"CL SPAN"** ('cl' stands for current loop) must be set equal to the maximum anticipated <u>range</u> in the water level, that is, the "cl Zero" + "cl SPAN" equals the level for which the PSE/RTU/D will output 20 mA.

Begin by accepting the password as described above.   Use *select* until the word **"CL SPAN"** appears. Press the *set/On* switch. Use the *Edit* switch to set the display equal to the proper value as described in APPENDIX B, then use *set/On* to enter this value.

NOTE that when entering values for the **"CL SPAN"** the decimal point must be present as these parameters are floating point variables. The "+" or "-" sign must also be entered for these parameters.   For instance, a "cl SPAN" of +4.000 may be entered as "+4." but not as "+4", "4." or "4". Use *set/on* repeatedly to review the list of parameters and their respective values.
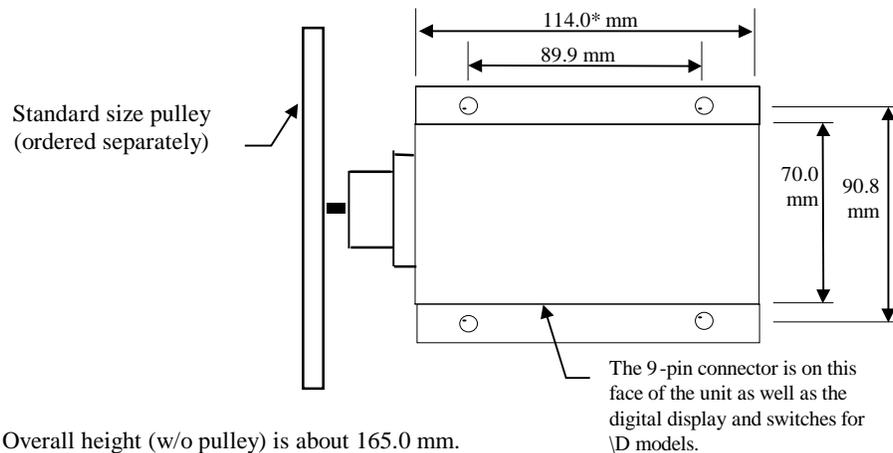
The default value for "CL SPAN" is +4.000.

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 the PSE/D/RTU consumes about 130 mA when the display is on.

4.   <u>Installation</u>

4.1. <u>Mechanical</u>

All AMASS Data Incremental Shaft Encoders may be attached to a flat surface using #10 bolts or screws through the six holes located in the mounting brackets on the PSE/RTU housing as shown in Fig.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 is mounted to the unit by means of the aluminium clamping assembly, which is threaded to the shaft. The clamping assembly accepts standard L&S or F&P pulleys. Any model may be used to indicate the position of any shaft, which can be coupled or geared to the encoder shaft. With suitable mechanical coupling, linear positions may also be measured. For more information on the physical characteristics of the PSE/RTU refer to *Specifications.*

Standard size pulley (ordered separately)

114.0* mm

89.9 mm

70.0 mm

90.8 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 165.0 mm.

* The length of the box is 120mm for models with built-in modem, for ex: PSE/RTU/MDM.

Figure 3. Top view of PSE/RTU(\D) with mounting feet 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.

4.2. 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 9 pin connector 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/RTU). If the connector is removed at the PSE/RTU, however, the current shaft position is lost and the unit must be reinitialized using the "SET" commands or the display and switches. This is because the connector closes the backup circuit through pins 7 and 9 (see *Connectors*), therefore, the 9V battery-backup facility becomes disabled if the cable is not mounted the unit. 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/RTU. The open circuit that results when the connector is not mounted means that the PSE/RTU can be stored without depleting the 9 V battery.

The PSE/RTU communications is via MODBUS RTU protocol (see 2. ModBUS RTU Interface). The hardware interface is thus RS485. The PSE/RTU may only be connected in FULL-duplex mode.
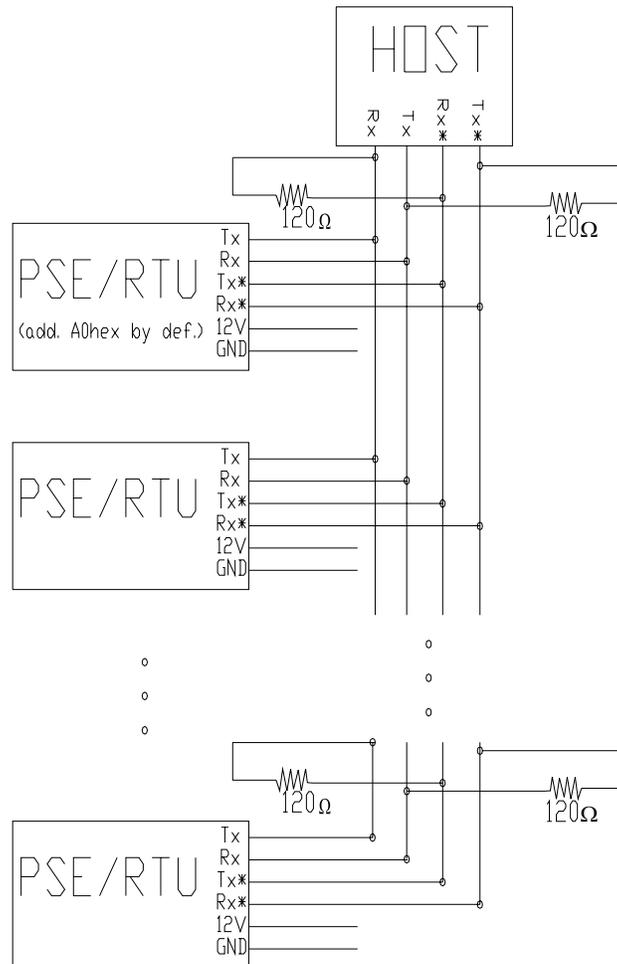
Up to 247 devices on the MODBus network. Default address is A0 hex (160 dec.).
Addresses: 1 to F7 hex.

4.3. Connectors

4.3.1. Standard PSE/RTU

1   9 pin AMP CPC+ Connector

Connections are as follows:

PIN	SIGNAL	Cable Color
1	+ 12 Vin	Red
2	Tx	Blue
3	Ground	Black
4	Rx* (or Rx-)	White
5	None[1]	none
6	Tx* (or Tx-)	Green
7	Ground	Jumper across 7and 9
8	Rx	Brown
9	Neg. terminal of +9V battery	Jumper across 7and 9

1. Pin 5 is used for an event counter input on rev D non-Modbus units as well as for the Alarm Input for models equipped with the "/ALI" option. Note, however, that the event counter may be wired to the DB15P connector on "/ALI" models.

4.3.2. PSE/RTU/MDM models

1   RJ11 Connector for telephone line
1   DB15P Connector

DB15P Pin Assignments (connected internally)

PIN	SIGNAL
1	Ground to PSE/RTU
3	**Event Counter Input for "ALI" option**
6	TxB Out to PSE/RTU from PMDM
7	+5V to PSE/RTU
8	Ground from power supply
9	**Event Counter Ground for "ALI" option**
12	RxB In from PSE/RTU to PMDM
15	+12V input from power supply

All other pins unassigned.

4.3.3. Relay Output

PSE/RTU shaft encoders that were shipped after July 1, 2003 are equipped with a software-controlled relay output. This output is provided by means of a reed relay which is rated up to 2 A.   Prior to July 1, 2003 this feature was indicated by option "/SW".

Alarm points that are user-configurable via the MODBus interface, or the LED display and operator switches (see section 3.6), control the relay.   These alarm points are the upper and lower limits of operation that usually correspond to flood and drought conditions.
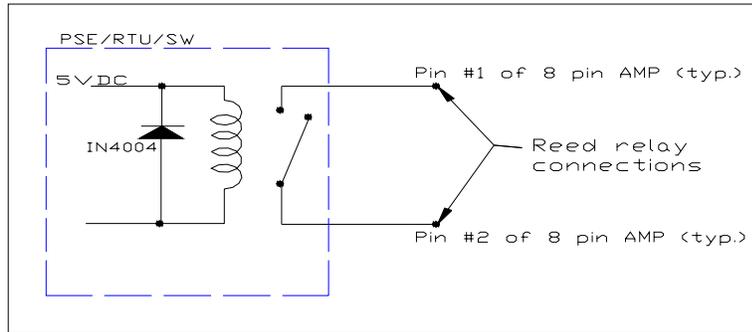

Figure 4. Configuration of internal relay in PSE/RTU.

4.3.4. Option \4-20

1   **8 pin AMP CPC connector**

PIN	SIGNAL	Cable Color
3	Current Loop (12 to 30 VDC)	Red
4	**Relay termination with option "/ALO"**	**Blue**
5	**Relay termination with option "/ALO"**	**Brown**
7	End of Current loop	White

Note that pins #1 and #2 of this connector are reserved for connection to the level-controlled internal relay (option "/SW" only, see section 4.3.3).

Note that pins #4 and #5 of this connector are reserved for connection to the internal relay which is included with option "/ALO". This relay is controlled by detection of a remote switch closure. This option is relevant to PRTU units only (Remote Terminal Unit) and corresponds to the "/ALI" option on the remote PSE/RTU/MDM/ALI.

4.4. Connection of 4-20 mA Current Loop (/4-20 only)

Connect the two wires of the current loop (see section 4.3.4) as shown below:
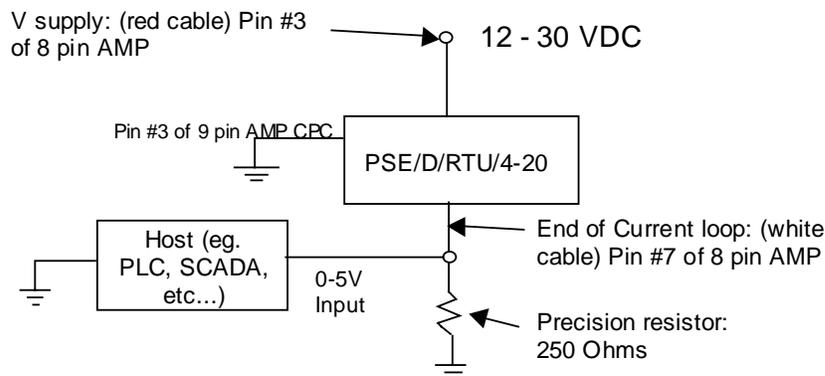
4.5. <u>Calibration of 4-20 Current Loop (/4-20 only)</u>

Once the PSE/RTU/4-20 is connected as shown above it must be calibrated. This is easily done with accurate results as follows:

1. Use the *Select* and *Set/on* switch positions until "**4mA out**" is displayed on the screen.
2. Using a voltmeter, measure the voltage across the precision 250-Ohm resistor. There should be exactly 1 V across the resistor. If it is not, remove the PSE/RTU panel from the enclosure and adjust the variable resistor labelled "**VR1**" until a 1 V reading is obtained.
3. Use the *Select* and *Set/on* switch positions until "**20mA out**" is displayed on the screen.
4. Using a voltmeter, measure the voltage across the precision 250-Ohm resistor. There should be exactly 5 V across the resistor. Adjust the variable resistor labelled "**VR2**" until a 5 V reading is obtained.
5. The calibration is done.

4.6. <u>Jumper Configuration</u>

In order to operate the PSE/D/RTU the user must ensure that proper jumper configuration is made (see Figure 5). For full-duplex operation there must be NO jumpers on '485', 'HC' and '485*'. 'JP5' should have a jumper installed.
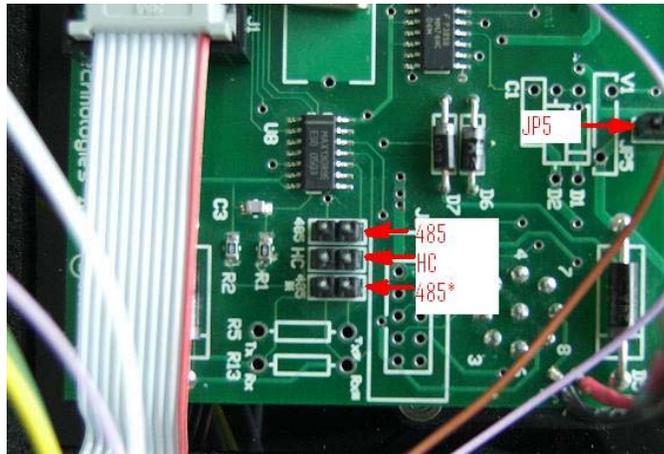

Figure 5. Location of 'HC', '485' and ' RS485*' jumper blocks.

5. Specifications

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

Shaft Encoder
C-Model
Sensor type - two channel optical incremental encoder 100 x 4 counts per revolution
Resolution - 400 counts per revolution; software conversion to engineering units provided in firmware. (Units per revolution)

Range
- +/-32.0 m (K series), +/-30.719m (C series) with .375 m circumference pulley
- +/-85.3 ft (K series), +/-81.918ft (C series) with 1.00 ft circumference pulley

Max. Response Speed
2.5 rev/sec.

Output
ASCII accumulated level using
- Slave MODBUS RTU protocol driver: Response Messages transmitted upon request via RS485 (standard) or modem (/**MDM** and /**MDMLL** options)

OR
- 4-20 mA current loop for host interface (/**4-20** option)

Connector
- 9 pin AMP CPC Connector for comm (standard)
- 15 pin DB15P conn. (/MDM models)
- 8 pin AMP CPC for relay output and 4-20mA ("/4-20" option only)

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

Power Consumption
< 5 mA quiescent current for a sample rate of once per second.
maximum current : < 30 mA (with "/D" display off)

Battery Backup
9 V 565 mAHr alkaline battery backup
(Only if connector is mounted)

Relay Output
Rated up to 2A.
Connects pin#2 to pin#1 of 8-pin CPC

Mechanical Interface

Maximum safe load
10 lb 4.5 kg.

Starting Torque
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 : Mounting brackets use four #10 bolts or screws.

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

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APPENDIX A: Register Assignments

Register(s)	Value
1 & 2	Shaft encoder position
3	16-bit encoder count/Comm. Status (PRTU only)
4	Shaft encoder SCALE
5 &6	Shaft encoder OFFSET
7 &8	Upper Alarm Level
9 &10	Upper Alarm Reset
11 & 12	Lower Alarm Level
13 & 14	Lower Alarm Reset
15	MODBus RTU Address

NOTE: Registers can only be written simultaneously if they represent a single value. For instance, registers 1 & 2 can be written simultaneously, but 3 and 4 cannot. Registers 3 and 4 must be written using separate commands.

APPENDIX B: Determining "CL ZERO" and "CL SPAN" (/4-20 option)

In order for the PSE/RTU to properly convert the data to a 4-20 mA output (option "**/4-20**" only) it is necessary to define the values **"CL ZERO"** and **"CL SPAN"**. The parameter **"CL ZERO"** must be set equal to the <u>minimum anticipated value</u> in the water level. The parameter **"CL SPAN"** must be set equal to the <u>maximum anticipated range</u> in this data.

<u>Example</u>:

Assume the lowest possible water level is 130.000 and that the highest is 140.000. You must enter a value of 130.000 for the "CL ZERO" and 10.000 for the "CL SPAN" using the display and switches (\D option only) or proper MODBUS RTU command. Therefore, a value of 132.500 would generate 8mA in the current loop as such

[{(Sensor data) – **"CL ZERO"**} **X 16/"CL SPAN"**] + **4 = current output**

[{(132.500) – 130.000} **X 16/10.000**] + **4 =** 8mA

APPENDIX C: PSE/RTU ERROR MESSAGES

The following error codes may be transmitted by the PSE/RTU:

Error Code	Meaning
Er1	Invalid transmission length
Er3	Incorrect checksum
Er4	Tx buffer overflow
Er5	Invalid command (if checksum is correct, otherwise 'Er3' is returned)