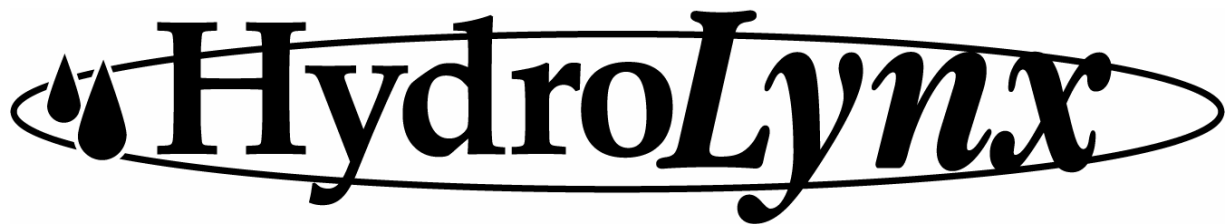


HydroLynx Systems, Inc.

**Model 50386SE-109
SDI-12 Shaft Encoder with Display**

Instruction Manual



Document No: A102720-2
Document Revision Date: September, 2010

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Equipment Configuration and Parts Identification

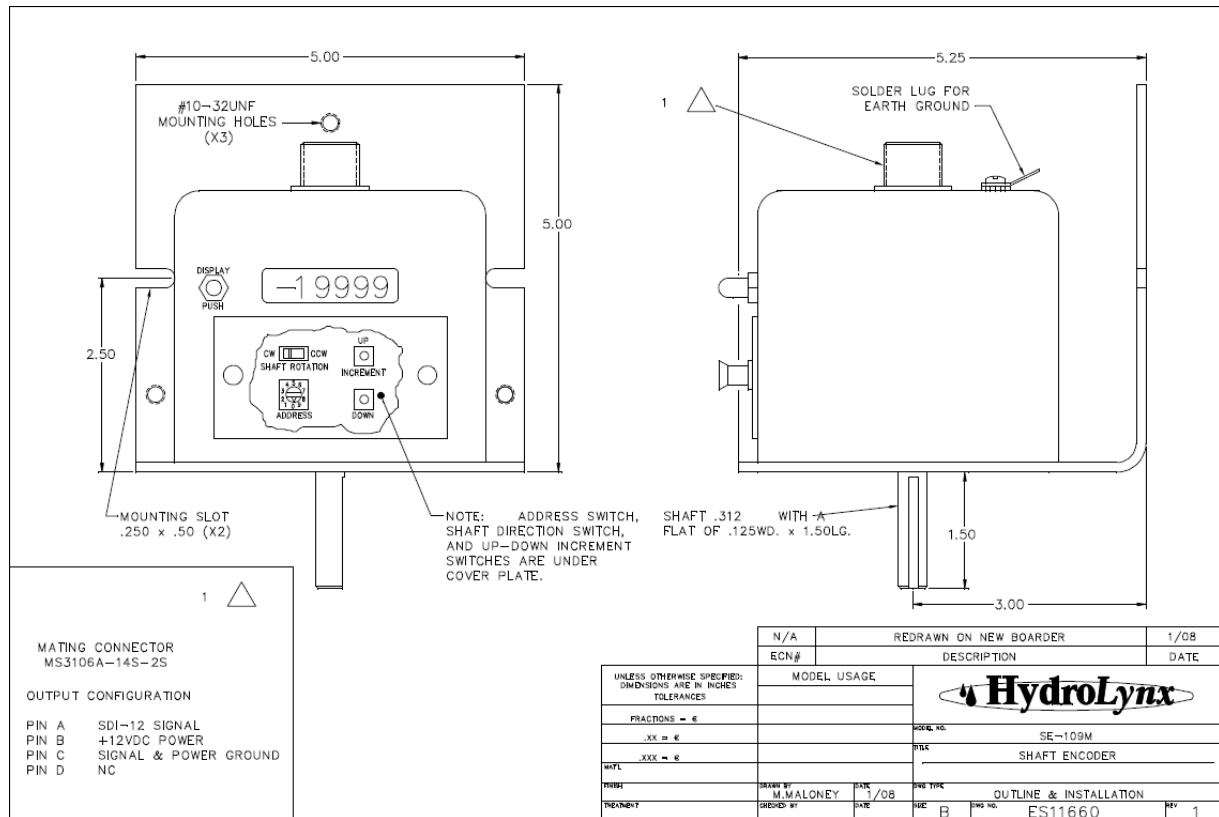


Figure 1: 50386SE-109 Standard Configuration

1 INTRODUCTION

1.1 General Description

The Model 50386SE-109 SDI-12 Shaft Encoder with Display is a low-power shaft encoder designed for battery-powered field operation for the measurement of water level or floodgate position. The internal microprocessor allows the encoder to emulate an absolute encoder. The user may set the initial water level, read and adjust subsequent levels through the SDI-12 interface. The encoder operates with standard float tape or bead chain pulleys and float hardware.

A 6-digit LED display is provided on the top face for viewing data at the site location. Switches for setting and adjusting the stage (water) level, the SDI-12 address, and shaft rotation increment direction are located beneath a protective cover on top of the encoder. This feature allows the Shaft Encoder to be set up in the field without the use of a computer or special programming in the data logger.

1.2 Equipment Included

- 1> 50386SE-109
- 2> Pulley
- 3> Optional 9V NiCad battery backup

1.3 Specifications

| | |
|-----------------------|---|
| Power | 10 to 16Vdc, reverse polarity protected. |
| Power Dissipation | <2.0mA at 13.6Vdc, 28mW standby, <= 125 mA when display is active. |
| Full Scale | Full scale is limited to 7 digits plus 2 for the decimal and sign. Full scale is -99999.99 to +99999.99 or -9999.999 to +9999.999. The starting number after power on reset is set to 0. |
| Scaling | Scaling is determined by a user entered value. The scaling value determines the increment for each count of the shaft rotation. For positive scaling values, the output count increases for clockwise rotation. For negative scaling values, the output count decreased for clockwise rotation. |
| Counts per Turn | The Shaft Encoder may be user programmed for 100 or 400 counts per revolution. |
| Resolution | The Shaft Encoder may be use programmed for output resolution of 0.01 or 0.001. |
| Serial Communications | 1200 baud, 7 data bits, even parity, 1 stop bit using standard ASCII character set. All communications recognize an address which is set by an internal switch. The serial output is tri-stated during inactivity to allow for single wire half-duplex operation. Conforms to SDI-12 version 1.2 Specification. |

2 INSTALLATION

The 50386SE-109 Shaft Encoder uses optical couplers with a slotted disc to measure rotation and may be mounted in any position. The unit requires a pulley but does not require the hub assembly used on earlier assemblies as the count value can be changed with a PC computer or through the recording instrument interface, or by using the UP and DOWN switches with the Display. The mounting bracket provides tapped holes for leveling screws. Figure 1 shows the 50386SE-109 outline and the mounting holes.

2.1 Optional Battery Backup

The 50386SE-109 Shaft Encoder is available with an optional 9 Vdc NiCad battery. The battery is factory installed and is charged when power is applied to the Shaft Encoder. The

backup battery option can be detected using the identification command and the battery condition can be measured using the verify command.

The Shaft Encoder cover will need to be removed to install the battery or replace a dead battery. The cover can be removed by removing the 2 screws from the rear of the unit and sliding the cover to the rear. Sufficient cable is supplied for the SDI-12 interface to allow the cover to be completely removed. Remove the old battery from the battery housing located one of the support brackets. Slide the cover back on and re-install the screws.

2.2 Connection to Shaft Encoder

The Shaft Encoder has the following standard SDI-12 connection.

| | |
|---|---------------|
| Standard 4-pin SDI-12 Interface Connector | |
| Connector Type: MS3102A-14S-2P | |
| Matting Connector: MS3106R-14S-2S | |
| Pin | Function |
| A | SDI-12 Signal |
| B | +12VDC |
| C | Ground |
| D | No Connection |

An optional 3 pin connections is available:

| | |
|---|---------------|
| Optional 3-pin SDI-12 Interface Connector | |
| Connector Type: MS3102S-10SL-3P | |
| Matting Connector: MS3106A-10SL-3S | |
| Pin | Function |
| A | +12VDC |
| B | SDI-12 Signal |
| C | Ground |

2.3 Operation

The standard Shaft Encoder operates with the SDI-12 protocol version 1.2. This protocol defines a hardware and software interface where data is transmitted and received over a single data wire.

2.4 Display Operation

The display can be operated by pressing the push-button located on the top of the 50386SE-109 Shaft Encoder. The display will indicate the current reading from -999.99 feet to 9999.99 for 2 digit resolution setting or -99.999 to 999.999 for 3-digit resolution setting. The display is updated with the new value every 1/2 second. If the 12Vdc input power is below 11Vdc, the display will flash indicating low input power. If the Shaft Encoder is operating from the internal battery because the external power is off or too low in voltage, the display will flash one decimal point and the value will not be displayed.

2.4.1 Setting Count Value

The current count value can be set using the UP or DOWN push button switches located behind a removable panel on the top of the unit. Each switch press will increment or decrement the count by 1. Holding the switch down will change the count faster. After a short time the count will change 10 times faster. Note: The display push-button switch must be pressed while pressing the UP or DOWN push buttons to change the count value.

2.4.2 Setting Count Direction

The count direction is set using a slide switch located behind a removable panel on the top of the unit. The switch is labeled CW (clockwise) and CCW (counterclockwise) and determines the direction of rotation required to make the count increase.

2.4.3 Setting the SDI-12 Address

The SDI-12 address is set using a 10-position rotary switch located behind a removable panel on the top of the unit. The switch sets the SDI-12 address from 0 to 9.

2.4.4 Entering the New Count Direction and SDI-12 Address

Changing the count direction slide switch or the SDI-12 address switch does NOT change the Shaft Encoder values. Press both the display, UP, and DOWN push buttons for about 1.5 seconds to change the state of the count direction and SDI-12 address to the value indicated by the switches. When the new value is accepted, the display will indicate the SDI-12 address in the left digit and the count direction in the right digit. The center digits will be blank. For CW (clockwise), the left display digit will indicate 'U' and for CCW (counterclockwise) the left display digit will indicate '-'.

2.5 SDI-12 Commands

The following describes the operation of the commands available through the interface. The 'a' in the following commands is the single character address.

2.5.1 Initiate Measurement

aM! Initiate a measurement. The Shaft Encoder returns a0001<CR><LF> indicating there is 1 measurement is available and it is available immediately. The data may be retrieved using the Return Data command **aD0!**. Commands **aM1!** through **aM9!** return a0000<CR><LF>.

2.5.2 Return Data

aD0! Returns data from a previous command. An example of the returned data from an Initiate Measurement command is shown below. The Shaft Encoder does not respond to **aD1!** through **aD9!**.

```
a+16.34<CR><LF>
| |           | |           |
| |           | +-----+----> Trailing CR LF
| +-----+-----> Data, + or - is data partition
```


The second value indicates if the Shaft Encoder has been reset since the last Verify command.

- 0 No reset
- 1 Software reset (watchdog timer timed out)
- 2 Power on reset
- 3 Both resets occurred
- 4 Reset caused by the internal reset pin
- 5 Reset caused by the execution of an illegal op code
- 6 Reset caused by an internal oscillator problem
- 7 Reset caused by low voltage to the microprocessor

A reset may indicate the count data is not valid. An invalid count is reset to the default count.

The third value indicates the results of a ram self test.

- 0 The ram test passed
- 1 The ram test failed

The fourth value indicates the results of the prom self test.

- 0 The prom test passed (prom checksum is OK)
- 1 The prom test failed (prom checksum does not match the computed value)

The fifth value indicates the results of the EEPROM self test.

- 0 The EEPROM test passed (EEPROM checksum is OK)
- 1 The EEPROM test failed (EEPROM checksum does not match the computed value)

The sixth value indicates the condition of the count value. The count value contains a checksum which is periodically tested. If the count value checksum is not valid, the default count value is loaded into the current count value. The default count value is contained in the EEPROM.

- 0 The count value checksum is OK
- 1 The count value has been reset to 0 because the count value checksum was invalid.

If the sixth value is set, it is reset after the verify command has been issued.

The seventh value is the input power voltage in Vdc.

The eighth value is the battery backup voltage in Vdc.

2.5.10 Special Commands

The following special commands are used to scale and test the Shaft Encoder. These commands may not be supported by the Data Logger. All special commands have the following format.

aXnxxxx! n is the special function number and xxxx may be 1 or more data points. Each data point begins with a '+' or '-' sign. Some special functions may return data which may be accessed using the **aD0!** command.

aXn! Returns the data associated with the special command. The data is retrieved using the **aD0!** command. Not all special commands support the return data feature.

2.5.10.1 Set Current Value

aX0+123.45! The Set Current Value command sets the current Shaft Encoder value to the data value attached to the command. For this example the current value is set to 123.45. The Shaft Encoder returns a<CR><LF> indicating it is ready to receive the next command.

2.5.10.2 Set Increment Value

Set the increment value and direction for each count. A positive Increment Value increments the Current Value when the pulley is rotated clockwise. A negative Increment Value increments the Current Value when the pulley is rotated counterclockwise.

Setting the Increment Value to a number larger than the Output Resolution precision (0.01 or 0.001), see Set Output Resolution command, **aX3!**, allows the Shaft Encoder value to increment in larger steps than the Output Resolution precision. For example, set the Output Resolution precision to 0.01 and the Increment Value to 0.05 to make the Shaft Encoder value increment by 0.05 for each count. If the value starts at 0.00, the first count increments the value to 0.05, the next count to 0.10, etc.

aX1! Read the Increment Value. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The data is retrieved using the **aD0!** command.

aX1+0.01! Set the Increment Value to 0.01. The current value will increment for clockwise pulley rotation. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!** command will be the original value.

aX1-0.0025! Set the Increment Value to -0.0025. The current value will increment for counter clockwise pulley rotation. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!**

command. If an error is detected, the value returned by the **aD0!** command will be the original value.

WARNING: Changing the Counts per Turn or Output Resolution automatically changes the Increment Value. Set these values first before setting the Increment Value.

2.5.10.3 Set Counts per Turn

The Counts per Turn sets the number of counts the Current Value is incremented for a complete revolution of the pulley. This value can be 100 or 400.

aX2! Read the Counts per Turn. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The data is retrieved using the **aD0!** command.

aX2+100! Set the Counts per Turn to 100. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!** command will be the original value.

aX2+400! Set the Counts per Turn to 400. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!** command will be the original value.

All other values are ignored.

WARNING: Changing the Counts per Turn automatically changes the Increment Value. Reset it with the Set Increment Value command, **aX1!**.

2.5.10.4 Set Output Resolution

The Output Resolution sets the number of digits to the right of the decimal point for the Current Value display precision. For example, an output resolution of 2 sets the Current Value display precision to 0.01. An output resolution of 3 sets the Current Value display precision to 0.001.

aX3! Read the Output Resolution. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The data is retrieved using the **aD0!** command.

aX3+2! Set the Output Resolution to 2 digits. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!**

command will be the original value.

aX3+3! Set the Output Resolution to 3 digits. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!** command will be the original value.

All other values are ignored.

WARNING: Changing the Output Resolution automatically changes the Increment Value. Reset it with the Set Increment Value command, **aX1!**.

2.5.10.5 Set ID Number

aX4! Read the Id Number. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The data is retrieved using the **aD0!** command.

aX4+12345! Set the Id Number to 12345. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!** command will be the original value. The ID number is readable using the Identify command. Acceptable values are 0 to 65535.

NOTE: The ID number is set to the PCB serial number by the factory.

2.5.10.6 Power On Reset

aX5! Power on reset. After receipt of this command the Shaft Encoder returns a<CR><LF> and performs a power on reset. The current count will not be changed. A power on reset activates battery charger commands.

2.5.10.7 Set Battery Backup Option Installed

This command is used to tell the hardware whether or not the battery backup option is installed. If the battery backup option is not installed the battery charging circuit is disabled, see Set Battery Charger command, **aX23!**.

aX6! Read the battery backup option installed state. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The data is retrieved using the **aD0!** command.

aX6+0! Disable battery backup option installed. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!**

command will be the original value.

aX6+1! Enable battery backup option installed. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!** command will be the original value.

All other values are ignored.

2.5.10.8 Set Maximum Rotation Speed

The maximum rotation speed command sets the maximum shaft rotation speed from 0.5 rotations per second to 5 rotations per second. The value may be set in 0.5 rotations per second increments. The current required to operate the Shaft Encoder is some what proportional to the rotation speed. This value is preset at the factory to 2.5 rotations per second. Input values of +.5, +1, +1.5, +2, +2.5, +3, +3.5, +4, +4.5 and +5 are acceptable. All other values are ignored.

aX7! Read the Maximum Rotation Speed. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameters ready in 1 second. The Shaft Encoder issues a service request when the current pulse options are available. The data is retrieved using the **aD0!** command.

aX7+2! Set the Maximum Rotation Speed to 2 rotations per second. The Shaft Encoder returns a0011<CR><LF> indicating the Shaft Encoder will have 1 parameter ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!** command will be the original value.

2.5.10.9 Set the Optocoupler Current

The Shaft Encoder contains 2 optocouplers to measure the position of the code disk. The 2 couplers are mechanically spaced so the output phasing is 90° apart. The current in the LED side of the couplers is adjusted so the output of the transistor side is a square wave when the shaft is rotated at a constant speed of 0.5 rotations per second. The first value sets the left coupler (IOS50) and the second changes the right coupler (ISO51). Valid values are 0 to 255.

aX13! Read the Optocoupler Current. The Shaft Encoder returns a0012<CR><LF> indicating the Shaft Encoder will have 2 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the left and right optocoupler current settings. For example:

```
a+59+57<CR><LF>
|   |   |
|   |   +-----> Right optocoupler current
```

```

| +-----> Left optocoupler current
+-----> Address
    
```

If an error is detected, the values returned by the **aD0!** command will be the original values.

aX13+61+63! Set the left Optocoupler Current to 61 and the right to 63. The Shaft Encoder returns a0012<CR><LF> indicating the Shaft Encoder will have 2 parameters ready in 1 second. The changed value may be verified by using the **aD0!** command. If an error is detected, the value returned by the **aD0!** command will be the original value.

NOTE: Save Optocoupler Current values to EEPROM with the **aX14!** command.

WARNING: Optocoupler current values are set by the factory. Do not change unless you have the proper calibration equipment.

2.5.10.10 Save the Optocoupler Current to EEPROM

Setting the optocoupler current using the X13, X17, X18, X19, X20, or X21 commands, adjusts the current with the values saved in ram. This means if power is cycled the values will change to the ones stored to EEPROM. After the currents have been adjusted, they need to be saved to EEPROM using this command.

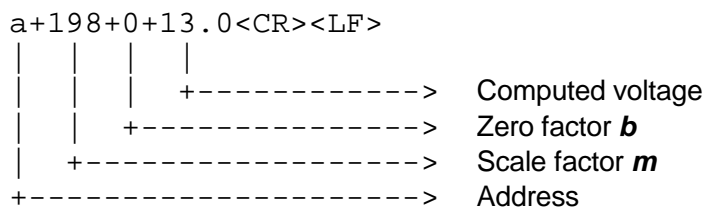
aX14! Save the Optocoupler Current to EEPROM. The Shaft Encoder returns a0012<CR><LF> indicating the Shaft Encoder will have 2 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the left and right current settings as read from the EEPROM.

2.5.10.11 Set the Input Voltage ADC Calibration

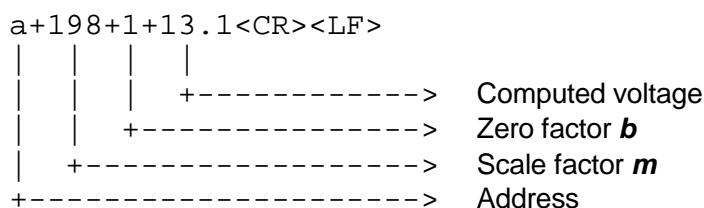
The Input Voltage ADC count is converted to voltage by the equation $y = (mx/256 + b)/10$ equation, where **m** is the scale factor and **b** is the zero factor. The scale factor has a range of 0 to 255 and the zero factor has a range of +127 to -128. The conversion process is done using 8 bit integer arithmetic. Under normal conditions the ADC value is 0 for 0 Volts and 176 for 13.6 Volts. The scale factor **m** is set to 198 and the zero factor **b** is set to 0.

$$\begin{aligned}
 Y &= (((198*170)/256)+0)/10 \\
 Y &= ((34848/256)+0)/10 \\
 Y &= (136 + 0)/10 \\
 Y &= 13.6
 \end{aligned}$$

aX15! Read the Input Voltage ADC Calibration. The Shaft Encoder returns a0031<CR><LF> indicating the Shaft Encoder will have 3 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the scale factor, the zero factor, and the computed voltage. For example:



aX15+198+1! Set the Input Voltage ADC Calibration scale factor **m** to 198 and zero factor **b** to 1. The Shaft Encoder returns a0031<CR><LF> indicating the Shaft Encoder will have 3 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the scale factor, the zero factor, and the computed voltage. For example:



If an error is detected, the values returned by the **aD0!** command will be the original values.

NOTE: Because of averaging in the Input Voltage calculations, the Input Voltage ADC Calibration may not show a change in the computed voltage until a second read request is made.

2.5.10.12 Set the Backup Battery Voltage ADC Calibration

The Backup Battery Voltage ADC count is converted to voltage by the equation $y = ((mx/256+b)/10)$ equation, where **m** is the scale factor and **b** is the zero factor. The scale factor has a range of 0 to 255 and the zero factor has a range of +127 to -128. The conversion process is done using 8 bit integer arithmetic. Under normal conditions the ADC value is 0 for 0 Volts and 176 for 13.6 Volts. The scale factor **m** is set to 198 and the zero factor **b** is set to 0.

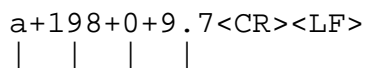
$$Y = (((198*170)/256)+0)/10$$

$$Y = ((34848/256)+0)/10$$

$$Y = (136 + 0)/10$$

$$Y = 13.6$$

aX16! Read the Backup Battery Voltage ADC Calibration. The Shaft Encoder returns a0031<CR><LF> indicating the Shaft Encoder will have 3 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the scale factor, the zero factor, and the computed voltage. For example:



```

|   |   |   +-----> Computed voltage
|   |   +-----> Zero factor b
|   +-----> Scale factor m
+-----> Address

```

aX16+200+0! Set the Backup Battery Voltage ADC Calibration scale factor **m** to 200 and zero factor **b** to 0. The Shaft Encoder returns a0031<CR><LF> indicating the Shaft Encoder will have 3 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the scale factor, the zero factor, and the computed voltage. For example:

```

a+200+0+9.9<CR><LF>
|   |   |   |   +-----> Computed voltage
|   |   +-----> Zero factor b
|   +-----> Scale factor m
+-----> Address

```

If an error is detected, the values returned by the **aD0!** command will be the original values.

NOTE: Because of averaging in the Backup Battery Voltage calculations, the Backup Battery Voltage ADC Calibration may not show a change in the computed voltage until a second read request is made.

2.5.10.13 Increment Left Optocoupler Current

The left optocoupler (ISO50) current is incremented by one count. The value can not be incremented above 255.

aX17! Increment the Left Optocoupler Current. The Shaft Encoder returns a0012<CR><LF> indicating the Shaft Encoder will have 2 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the left and right optocoupler current settings, see the Set Optocoupler Current command, **aX13!**.

NOTE: Save Optocoupler Current values to EEPROM with the **aX14!** command.

WARNING: This command is used by the factory to calibrate the Shaft Encoder. It requires the proper calibration equipment and is not recommended for field use.

2.5.10.14 Decrement Left Optocoupler Current

The left optocoupler (ISO50) current is decremented by one count. The value can not be decremented below 0.

aX18! Decrement the Left Optocoupler Current. The Shaft Encoder returns a0012<CR><LF> indicating the Shaft Encoder will have 2 parameters

ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the left and right optocoupler current settings, see the Set Optocoupler Current command, **aX13!**.

NOTE: Save Optocoupler Current values to EEPROM with the **aX14!** command.

WARNING: This command is used by the factory to calibrate the Shaft Encoder. It requires the proper calibration equipment and is not recommended for field use.

2.5.10.15 Increment Right Optocoupler Current

The right optocoupler (ISO51) current is incremented by one count. The value can not be incremented above 255.

aX19! Increment the Right Optocoupler Current. The Shaft Encoder returns a0012<CR><LF> indicating the Shaft Encoder will have 2 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the left and right optocoupler current settings, see the Set Optocoupler Current command, **aX13!**.

NOTE: Save Optocoupler Current values to EEPROM with the **aX14!** command.

WARNING: This command is used by the factory to calibrate the Shaft Encoder. It requires the proper calibration equipment and is not recommended for field use.

2.5.10.16 Decrement Right Optocoupler Current

The right optocoupler (ISO51) current is decremented by one count. The value can not be decremented below 0.

aX20! Decrement the Right Optocoupler Current. The Shaft Encoder returns a0012<CR><LF> indicating the Shaft Encoder will have 2 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The returned data is the left and right optocoupler current settings, see the Set Optocoupler Current command, **aX13!**.

NOTE: Save Optocoupler Current values to EEPROM with the **aX14!** command.

WARNING: This command is used by the factory to calibrate the Shaft Encoder. It requires the proper calibration equipment and is not recommended for field use.

2.5.10.17 Auto-calibrate Optocoupler Current

This command will set the initial values of the optocouplers. This is an automatic sequence and requires the board to be removed from the code disk and the optocouplers shielded from the ambient light source. Shielding the optocouplers with one's hand or turning the board so

the optocouplers face the surface is all that is required.

aX21! Auto-calibrate the Optocoupler Current. The Shaft Encoder returns a0092<CR><LF> indicating the Shaft Encoder will have 2 parameters ready within 9 seconds. The data is retrieved using the **aD0!** command. The returned data is the left and right optocoupler current settings, see the Set Optocoupler Current command, **aX13!**.

NOTE: Save Optocoupler Current values to EEPROM with the **aX14!** command.

WARNING: This command is used by the factory to set initial optocoupler current values before the Shaft Encoder is calibrated. It should not be substituted for a proper calibration with calibration equipment and is not recommended for field use.

2.5.10.18 Set Display Test Mode

This command puts the SE109M into a special test mode where the display, switches and push buttons can be used to test various functions. Sending a value +1 (or any non zero number) turns the display test mode on and a value of +0 returns the display to normal mode. See section 4.1.4 Display Test Mode for information on this test mode.

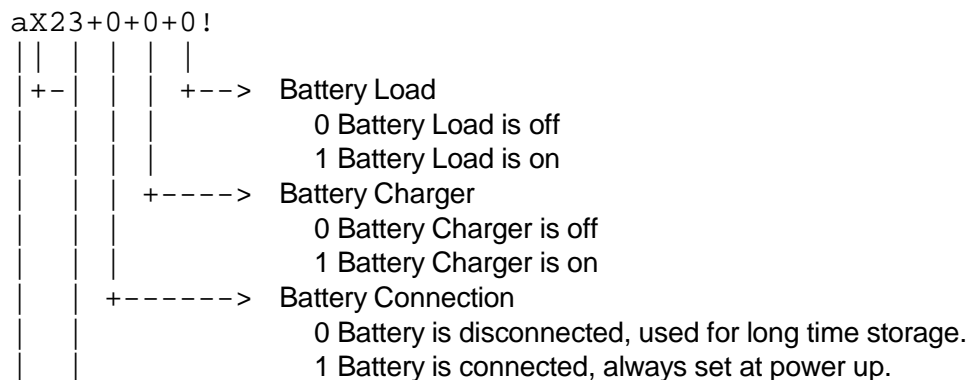
aX22+0! Turn off the display test mode. The Shaft Encoder responds with a<CR><LF>.

aX22+1! Turn on the display test mode. The Shaft Encoder responds with a<CR><LF>.

NOTE: The Shaft Encoder will not monitor shaft rotation while in the display test mode.

2.5.10.19 Set Battery Charger

This command allows control of the battery charging circuits so they can be tested. This command has 3 fields. Each field has a 0 or 1 value. It is not necessary to send all three fields. For example, if only the second field is to be changed, only the first and second field need be sent.



```

| +-----> Command
+-----> Address
    
```

aX23+0! Disconnect the battery from the charging circuit for long term storage. The Shaft Encoder responds with a<CR><LF>.

aX23+1! Connect the battery to the charging circuit. The Shaft Encoder responds with a<CR><LF>. This is the default state at power up unless the battery is not installed, see the Battery Backup Option Installed command, **aX6!**.

aX23+1+1! Connect the battery and turn on the battery charger. The Shaft Encoder responds with a<CR><LF>.

aX23+1+1+1! Connect the battery, turn on the battery charger, and turn on the battery load. The Shaft Encoder responds with a<CR><LF>.

NOTE: The battery charger commands are not activated until after a power up, power on reset command, **aX5!**, or the initiate verify command, **aV!**. The Shaft Encoder responds with a<CR><LF>.

2.5.10.20 Load Default Values

This command will load a set of default values into the EEPROM. The command is used at the factory during initial testing of the printed circuit board. The parameter data must be 31416

aX24+31416! Load Default Values. The EEPROM is erased and the default values loaded. The Shaft Encoder performs a power on reset when completed so no data is returned. The Shaft Encoder responds with a<CR><LF>.

WARNING: This command resets the optocoupler current values and requires a factory re-calibration of the Shaft Encoder.

2.5.10.21 Read Optocoupler Collector Voltage

This command displays the current value of the optocouplers in ADC counts ranging from 0 to 255. When LED is blocked the values will be above 224. When the LED is not blocked the value will be less than 32.

aX25! Read Optocoupler Collector Voltage. The Shaft Encoder returns a0012<CR><LF> indicating the Shaft Encoder will have 2 parameters ready in 1 second. The data is retrieved using the **aD0!** command. The command returns the left optocoupler value (IOS50), followed by the right optocoupler value (ISO51). For example:

```

a+13+14<CR><LF>
|   |   |
|   |   +-----> Right optocoupler collector voltage
|   +-----> Left optocoupler collector voltage
    
```

+-----> Address

3 THEORY OF OPERATION

The SE109M contains 5 major function blocks consisting of power supply, microprocessor and optical sensors, SDI interface and display. The operation of each section will be explained in the following paragraphs.

3.1 Power Supply

The power supply generates the operating voltages from the input power and provides for the battery backup. Over-voltage and reverse voltage protection is provided by F1, D2, D3 and GAP3. R2 and R1 divide the voltage so it can be measured by the ADC in the microprocessor. Primary 3.3V is provided by switching regulator U1. +5V for the SDI input and output is generated by linear regulator U6. Switch U11 disconnects the battery from the system and is controlled by the microprocessor. The micro will automatically disconnect the battery when the battery voltage falls below 7.0V. Switch U10 controls the charging of the battery. When U10 is on, the input voltage is applied to the battery through current limit resistor R14. The battery is charged for 16 hours when power is applied to the SE109M. It is also charged for 5 minutes everyday and for the same length of time power is removed from the unit limited to 16 hours maximum. Resistors R22 and R24 divide the voltage so the battery voltage can be measured by the ADC in the microprocessor. Q4 applies a load to the battery whenever the verify command is issued so the returned value is the battery voltage under load. Finally the battery current is converted to voltage by R15 and measured by the ADC in the microprocessor.

3.2 Microprocessor and Optical Sensors

The microprocessor's oscillator is derived from crystal Y1 and operates at 4.91MHz. This frequency is used as it generates the 1200 baud oscillator for the SDI interface. The microprocessor contains the UART used for the SDI interface, an ADC, timers, SPI interface which connects to the EEPROM U3 and display driver U4 and general purpose IO. The general purpose IO is used to interface with the battery charger control circuits, SDI address switch (S3), count direction switch (S2), the count up push button (S1) and the count down push button (S4). There are also chip select lines for U3 and U4 and the display on push button. The pull-up resistors for the SDI address switch and count direction switch is controlled by the microprocessor and is only active when the display push button is pressed.

The optocouplers are measured and controlled by the microprocessor. The power to the optocoupler LEDs is controlled by the microprocessor and is only turned on when a measurement is being made. The frequency is determined by the maximum shaft rotation speed and is computed as 400 times the rotation speed. So if the rotation speed is set to 2.5 rotations per second, then the optos are measured 1000 times per second. The current through the LED side of the optos is controlled by opamps U8 and U9. These amplifiers have enable inputs that are controlled by a timer inside the micro. So when the opamps are enabled, the current is set by the voltage on pin 3. This voltage is determined by resistor dividers and the output of a PWM (pulse width modulator) inside the micro. After the LEDs have been on for a while, the voltage at the collectors of the optos are measured by the ADC located in the microprocessor. The value of this voltage determines if the shaft is rotating

and the direction of rotation.

3.3 SDI Interface

The microprocessor operates from 3.3V and the SDI interface operates from 5V so the input and output to the UART must be level shifted. A comparator (U7) handles the SDI12 output. The bipolar output is tri-stated by the OUTON enable line on pin 5 of U7. The SDI12 input side goes through U6 and its output is diode isolated by D1 which provides the 5V to 3.3V level shift.

3.4 Display

The microprocessor operates from 3.3V and the SDI interface operates from 5V so the input and output to the UART must be level shifted. A comparator (U7) handles the SDI12 output. The bipolar output is tri-stated by the OUTON enable line on pin 5 of U7. The SDI12 input side goes through U6 and its output is diode isolated by D1 which provides the 5V to 3.3V level shift.

4 TESTING, CALIBRATION, AND MAINTENANCE

Once the 50386SE-109 Shaft Encoder is installed, proper operation is verified by reading levels with the Display or the SDI-12 Continuous Measurement command **aR0!**.

4.1 Testing

The shaft encoder can be tested with the Display by removing the panel on top of the Shaft Encoder. Press the DISPLAY push-button on the top of the Shaft Encoder to turn on the LED display. The LED display will turn off after 10 seconds. Press the DISPLAY push-button again to turn on the display.

The shaft encoder can also be tested with a DCU, DCP, data logger, or PC software program that can supports SDI-12 version 1.2 commands. The HydroLynx Systems 50386 Data Communication Unit (DCU) can be used to perform this testing. Use the SE109.sdi SDI-12 script file to simplify the testing.

4.1.1 Test Sensor SDI-12 Address

- Check the SDI-12 Address:
 - Verify the SDI-12 Address on the 10-position rotary ADDRESS switch located behind a removable panel on the top of the unit.
 - Read the sensor SDI-12 address with the Address Query command **?!** and verify that your test program is set to the correct address.
- Change the SDI-12 Address:
 - Set the sensor SDI-12 address with the Set Address command **aAb!**.
 - Set the sensor SDI-12 address with the ADDRESS rotary switch.
 - Set the sensor SDI-12 address in the ADDRESS rotary switch.
 - Press the DISPLAY push-button on the top of the Shaft Encoder to turn on the LED display.
 - Press and hold the UP and DOWN switches until the LED displays the SDI-12

address on the left side of the display. The right side of the display will show the SHAFT ROTATION switch position: U for CW (clockwise) or – for CCW (counter clockwise).

4.1.2 Test Output Resolution

- Read the Current Value:
 - Read the current value on the display.
 - Read the Current Value with the SDI-12 Continuous Measurement command **aR0!**.
- Check the display precision. An Output Resolution of 2 displays two digits to the right of the decimal point. An Output Resolution of 3 displays three digits to the right of the decimal point.
- Change the Output Resolution with the **aX3+2!** or **aX3+3!** command.

4.1.3 Test Counts per Revolution

- Read the Current Value:
 - Read the current value on the display.
 - Read the Current Value with the SDI-12 Continuous Measurement command **aR0!**.
- Check the Increment Direction:
 - Check the CW/CCW slide switch position. The CW position increments the Current Value when the pulley is rotated clockwise. The CCW position increments the Current Value when the pulley is rotated counterclockwise.
 - Read the Increment Value with the SDI-12 **aX1!** command. A positive Increment Value increments the Current Value when the pulley is rotated clockwise. A negative Increment Value increments the Current Value when the pulley is rotated counterclockwise.
- Read the Counts per Turn with the SDI-12 **aX2!** command to determine the number of increments for a full rotation of the pulley (100 or 400).
- Change the Counts per Turn with the **aX2+100!** or **aX2+400!** command.
- Rotate the pulley one complete turn in the positive increment direction (clockwise for positive Increment Value).
 - Observe the level in the display or read the Current Value with the SDI-12 Continuous Measurement command **aR0!**.
 - Verify that the level has incremented by the Counts per Turn (100 or 400).
- Rotate the pulley one complete turn in the negative increment direction (counterclockwise for positive Increment Value).
 - Observe the level in the display or read the Current Value with the SDI-12 Continuous Measurement command **aR0!**.
 - Verify that the level has decremented by the Counts per Turn (100 or 400).

4.1.4 Test Increment

- Read the Current Value:
 - Read the current value on the display.
 - Read the current value with the SDI-12 Continuous Measurement command **aR0!**.
- Check the Increment Direction:
 - Check the CW/CCW slide switch position. The CW position increments the Current

- Value when the pulley is rotated clockwise. The CCW position increments the Current Value when the pulley is rotated counterclockwise.
- Read the Increment Value with the SDI-12 **aX1!** command. A positive Increment Value increments the Current Value when the pulley is rotated clockwise. A negative Increment Value increments the Current Value when the pulley is rotated counterclockwise.
 - Set the Increment Direction:
 - Set the Increment Value with the SDI-12 **aX1±.xxx!** command. A positive Increment Value increments the Current Value when the pulley is rotated clockwise. A negative Increment Value increments the Current Value when the pulley is rotated counterclockwise.
 - Set the Increment Direction with the SHAFT ROTATION switch.
 - Set the SHAFT ROTATION switch to CW for a positive increment when the pulley is rotated clockwise. Set the switch to CCW for a positive increment when the pulley is rotated counter clockwise.
 - Press the DISPLAY push-button on the top of the Shaft Encoder to turn on the display.
 - Press and hold the UP and DOWN switches until the LED displays the SDI-12 address on the left side of the display. The right side of the display will show the SHAFT ROTATION switch position: U for CW (clockwise) or – for CCW (counter clockwise).
 - Rotate the pulley in the positive increment direction (clockwise for positive Increment Value):
 - Observe the level in the display or read the Current Value with the SDI-12 Continuous Measurement command **aR0!**.
 - Verify that the level has incremented.
 - Rotate the pulley in the negative increment direction (counterclockwise for positive Increment Value):
 - Observe the level in the display or read the Current Value with the SDI-12 Continuous Measurement command **aR0!**.
 - Verify that the level has decremented.

4.1.5 Display Test Mode

Send the Set Display Test Mode SDI-12 **aX22+1!** command. The LED display will turn on. Select the test number in the ADDRESS rotary switch and press the DOWN switch. The LED will display the test data.

| ADDRESS | Test Description |
|---------|---|
| 0 | Display/set optocoupler current. The LED display shows the selected optocoupler as a symbol on the left and the optocoupler current in hexadecimal on the right. Change the selected optocoupler with the SHAFT ROTATION switch. CW selects the left optocoupler (-) and CCW selects the right optocoupler (-). Press the UP switch to increase the optocoupler current; press the DOWN switch to decrease. |
| 1 | Display all LED segments. The LED display will show 8.8.8.8.8.8. |
| 2 | Display single LED segments. The LED display will show one LED segment at a time. |

- 3 Turn off all LED segments.
- 4 Show battery charger currents.
 - a. The first display is the charger current with no load. 1 is shown on the left and the current should read about 10.6 mA.
 - b. Press the DOWN switch to display the charger current with load. 2 is shown on the left and the current should read about 20.3 mA.
 - c. Press the DOWN switch to display the charger off current with load. 3 is shown on the left and the current should read about 0.1 mA.
 - d. Press the DOWN switch to display the charger off current with no load. 4 is shown on the left and the current should read 0.0 mA.
- 5 Show internal battery voltage with the charger on. It should read about 11.6Vdc.
- 6 Show external 12Vdc power voltage.
- 7 Show left and right optocoupler voltages. When fully blocked, the voltages should be between 0A and 16. When fully open, the voltages should be above F0.
- 8 Reserved for future use.
- 9 Reserved for future use.

Reset the ADDRESS rotary switch to the SDI-12 address, the SHAFT ROTATION switch to the increment direction, CW/CCW, and send the Set Display Test Mode SDI-12 **aX22+0!** command. The LED display will turn off.

4.2 Calibration

- Set the Current Value:
 - Hold down the Display push button and press the UP button to increment or the DOWN button to decrement the Current Value. Holding the UP or DOWN button down will change the count faster. Continuing holding the button down will change the count 10 times faster.
 - Set the Current value with the SDI-12 **aX0±x.xx!** command and verify the Current value with the SDI-12 Continuous Measurement command **aR0!**.

4.3 Maintenance

The 50386SE-109 Shaft Encoder is essentially a maintenance free instrument; while the stilling well or servo manometer will require periodic maintenance. During this periodic maintenance HydroLynx recommends:

- Check to see that the Shaft Encoder is level.
- Check to see that all moving parts are free from obstruction.
- Verify the Current Value.
- Verify the Display operation.

4.4 Troubleshooting

4.4.1 Visual Inspection

- Check the signal cable and connections.
- Check the float tape for binding.

4.4.2 Testing

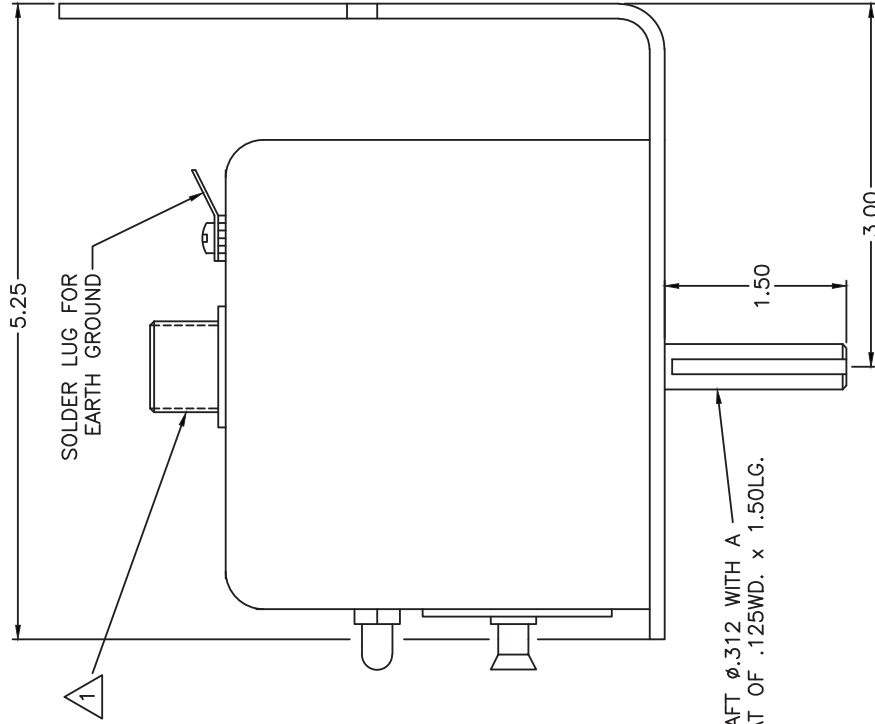
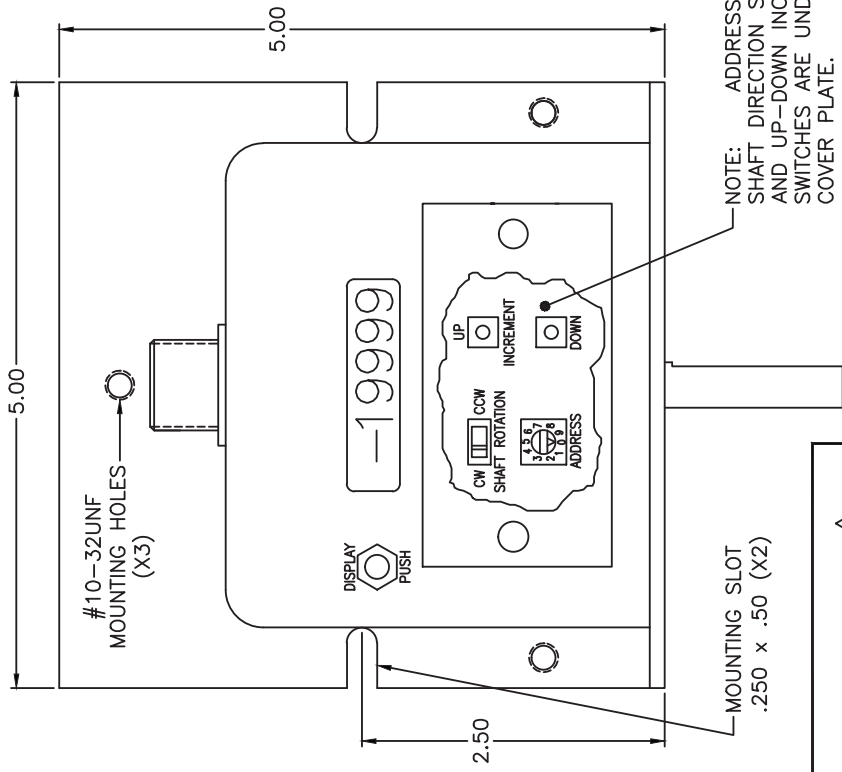
- Perform tests outlined in section 4.1
- No communication indicates a signal cable, connection, or PCB problem.
- Incorrect counts indicate a calibration problem of the optocouplers or PCB failure. Return the unit to the factory.

5 FORMS AND DRAWINGS

ES11660 50386SE-109 Outline and Installation

ES11661 Assembly, Cable, SDI-12, 4-pin

ES11709-1 Assembly, Cable, SDI-12, 3-pin



MATING CONNECTOR
MS3106A-14S-2S

OUTPUT CONFIGURATION

- PIN A SDI-12 SIGNAL
- PIN B +12VDC POWER
- PIN C SIGNAL & POWER GROUND
- PIN D NC

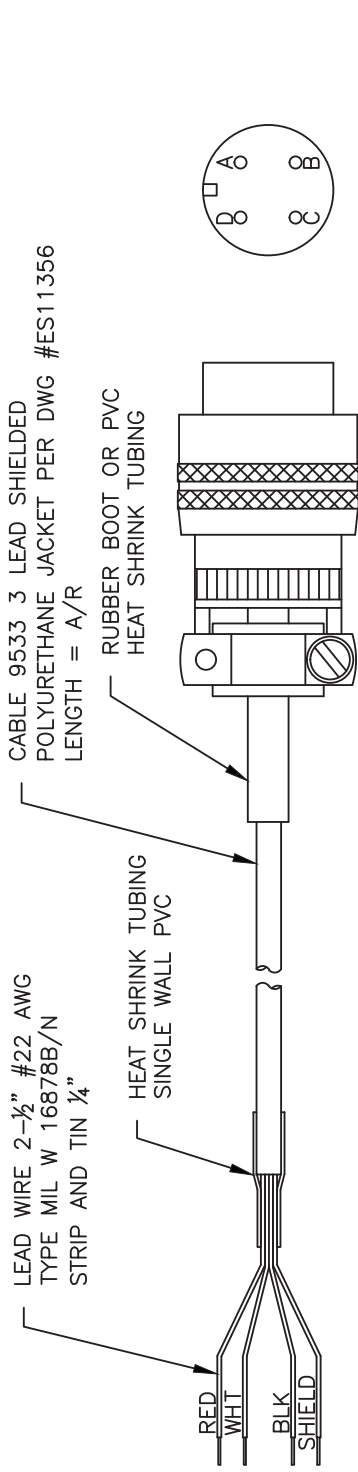
NOTE: ADDRESS SWITCH,
SHAFT DIRECTION SWITCH,
AND UP-DOWN INCREMENT
SWITCHES ARE UNDER
COVER PLATE.

SHAFT ϕ .312 WITH A
FLAT OF .125WD. x 1.50LG.

| | | |
|---|------------------------|-----------------|
| N/A | REDRAWN ON NEW BOARDER | 1/08 |
| ECN# | DESCRIPTION | DATE |
| MODEL USAGE | | |
| UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES TOLERANCES | | |
| FRACTIONS = ± | | |
| .XX = ± | | |
| .XXX = ± | | |
| MAYL | | |
| FINISH | | |
| DRAWN BY M.MALONEY | DATE 1/08 | DWG TYPE B |
| CHECKED BY | DATE | SIZE ES11660 |
| OUTLINE & INSTALLATION | | REV 1 |



MODEL NO. SE-109M
TITLE SHAFT ENCODER



LEAD WIRE CODE

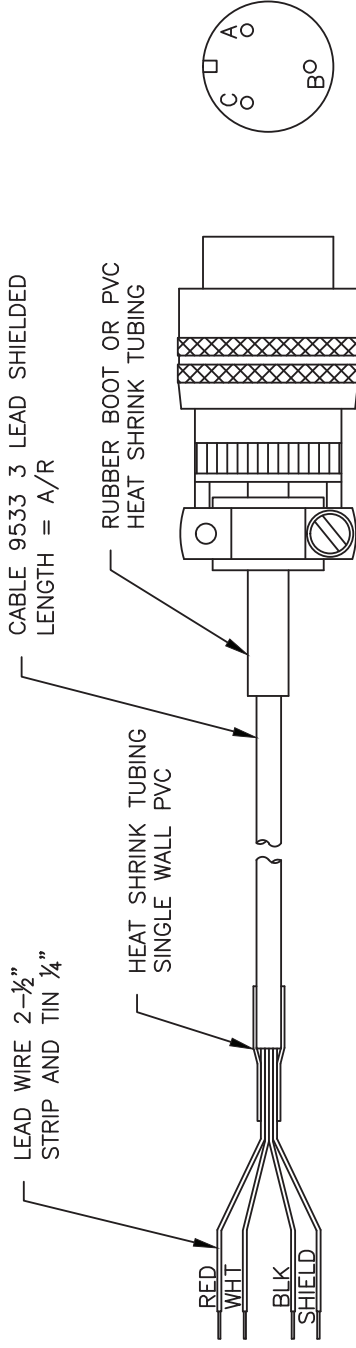
- RED = +12VDC
- WHT = SDI-12 SIGNAL
- BLK = POWER SIGNAL COMMON
- SHIELD WIRE = CLEAR TUBING OVER BARE DRAIN WIRE

CABLE ASSEMBLY
MODEL CA-109M-XXX & CA-105

CONNECTOR
MS-3106A-14S-2S

- BACK VIEW
- A = SDI-12 SIGNAL (WHT)
 - B = +12VDC (RED)
 - C = GROUND (BLK)
 - D = NC

| | | |
|----------------------|--------------------|------|
| ECN# | DESCRIPTION | DATE |
| MODEL USAGE | HydroLynx | |
| MODEL NO. | SE-105 & SE-109 | |
| TITLE | CABLE, SDI | |
| DWG TYPE | ASSY | |
| DRAWN BY MMALONEY | DATE 1/08 | |
| CHECKED BY | DATE | REV |
| SIZE A | DWG NO. ES11661 | |



LEAD WIRE CODE

- RED = +12VDC
- WHT = SDI-12 SIGNAL
- BLK = POWER SIGNAL COMMON
- SHIELD WIRE = CLEAR TUBING OVER BARE DRAIN WIRE

CABLE ASSEMBLY
 MODEL CA-109M-XXX & CA-105

CONNECTOR
 MS-3106A-14S-2S

BACK VIEW
 A = +12VDC (RED)
 B = SDI-12 SIGNAL (WHT)
 C = GROUND (BLK)

| | | |
|-------------------------------------|---|---------|
| 1 | CHANGED MS PIN OUTPUT (C TO A) & (A TO C) | 12/8/08 |
| ECN# | DESCRIPTION | DATE |
| MODEL USAGE | | |
| | | |
| MODEL NO. SE-105 & SE-109 | | |
| TITLE CABLE, SDI | | |
| DWG TYPE W/ MINI 3-PIN MS CONNECTOR | | |
| DRAWN BY MMALONEY | DATE 4/08 | ASSY |
| CHECKED BY | DATE | SIZE A |
| | DWG NO. ES11709 | REV 1 |