

MULTIPLE INTERFACE SHAFT ENCODER MODEL 56-0540



OPERATIONS & MAINTENANCE MANUAL

Part No. 8800-1137
Revision - B
7-Oct-04
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1. Introduction

The SDI-12 Incremental shaft encoder Model No. 56-0540 is designed to provide high reliability, versatility, low maintenance, and still meet the low power requirements of typical remote operations. It has been designed with the following features to operate in a wide range of applications:



Features

- Low power consumption
- High accuracy & excellent stability
- Supports Metric or English configurations
- Non-volatile setup
- Wide operating voltage
- Built-in 2 line by 8 character display with backlight
- Auto shut-off display to minimize total current consumption
- Externally mounted read button allows current stage reading to be displayed
- Externally Accessible internal AA battery back-up in case of main power loss.
- Varistor and spark gap transient protection
- User selectable clockwise/counterclockwise operation
- Strobed-optical design for precision counting and greater accuracy in shaft revolution error detection
- Communication interfaces: SDI-12, SDI-12 over RS-485 and RS-232.

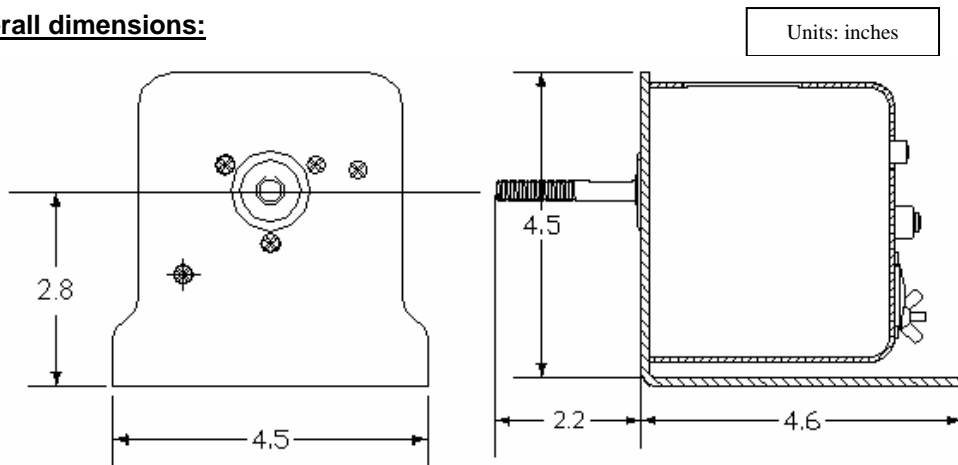
Unpacking

Remove the shaft encoder from the shipping container and visually inspect the unit for signs of damage during shipment. Additionally, rotate the shaft and note any grinding, scraping, or other mechanical problems found. Report any such damage to the factory immediately to ensure a prompt response and resolution. Retain one shipping container in the event a factory return is necessary.

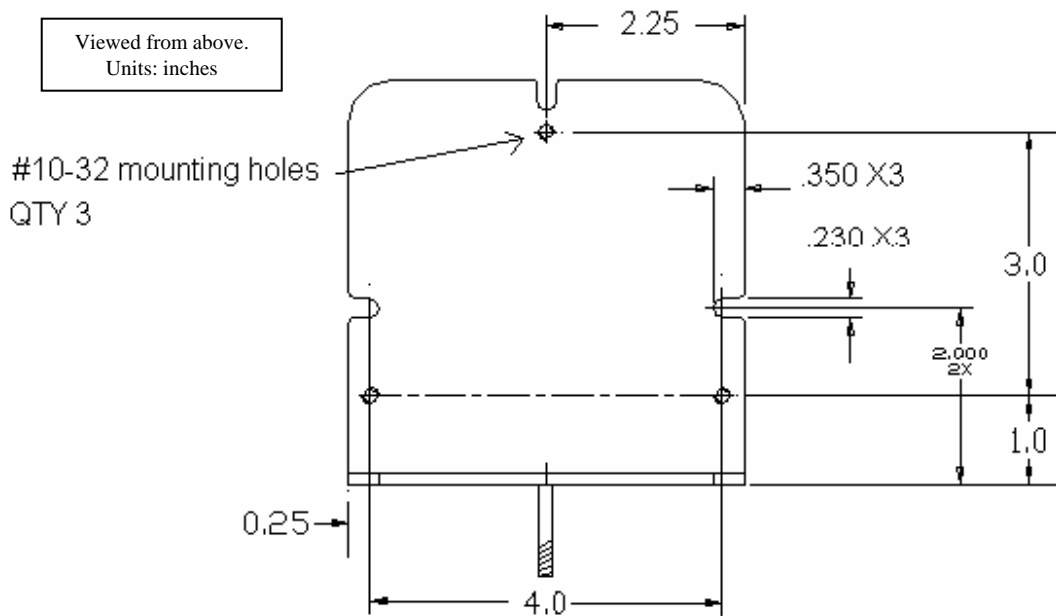
Please note that if a return is required, one must first obtain a return material authorization (RMA) number by calling the Sutron Customer Service Department.

Mechanical Features

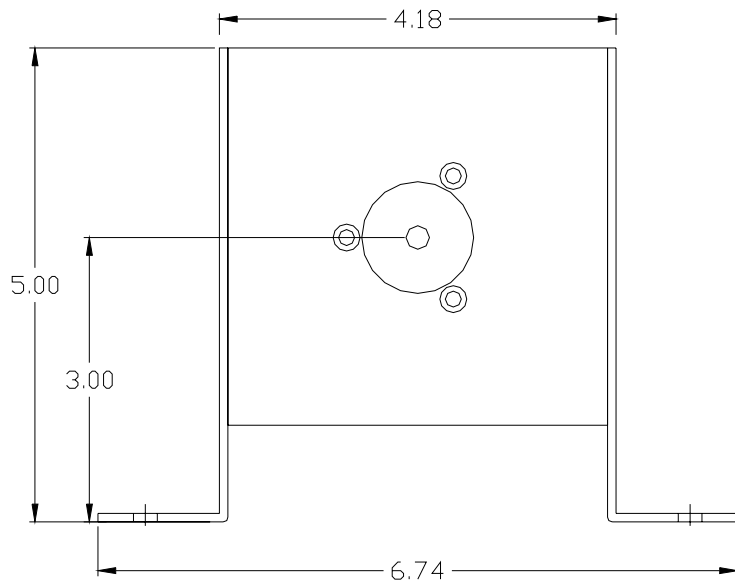
-DT & -DM Overall dimensions:



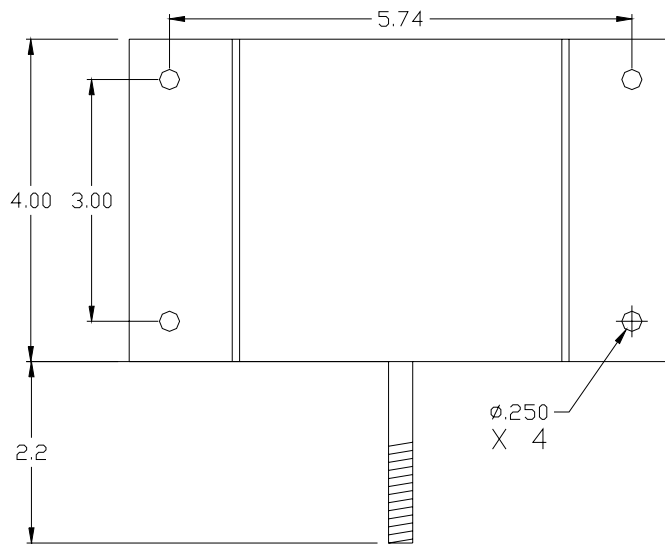
Mounting footprint:



-DTR Overall dimensions:



Mounting footprint:



2. Quick Start for Sutron Data Loggers

The shaft encoder sensor is designed to operate with a wide variety of data recorders or other equipment. If you plan to use the RS-232 or RS-485 connection, refer to Chapter 3 of this manual.

The following sections describe the steps to connect the shaft encoder to Sutron's popular data loggers. These steps install the shaft encoder in its default configuration. After following these steps, you will still need to perform some additional setup such as setting the direction of rotation, wheel size and current level. These steps are described in Chapter 4, Setup and Operation.

8200/8210

To use the shaft encoder with the 8200 or 8210, follow these steps:

- Connect the sensor PWR IN +, PWR IN G, and SDI DATA terminals to your Sutron 8200 / 8210 Data Logger SDI-12 port.
8210: PWR IN+ to SDI-12 +, PWR IN G to SDI-12 G, and SDI DATA to SDI-12 D
8200: PWR IN+ to Pin 9 of DB9, PWR IN G to Pin 7 of DB9, and SDI DATA to pin 1 of DB9
- Use the 8200/8210 SYSTEM SETUP\ENABLE SENSOR menu to turn SDIO-1 ON. If you want to see the shaft status also, turn SDIO-2 ON. Refer to the [Sutron 8210/8200A Data Logger Operations Manual](#) if you do not know how to ENABLE sensors.
- Use the 8200/8210 VIEW\LIVE READINGS menu and select the SDIO-1 sensor.

The 8200 or 8210 will now display the level readings from the shaft encoder.

Xpert/Xlite

To use the shaft encoder with the Xpert/Xlite, follow these steps:

- Connect the sensor PWR IN +, PWR IN G, and SDI DATA terminals to your Sutron Xpert/Xlite Data Logger SDI-12 port
Xpert: PWR IN+ to SDI +, PWR IN G to SDI G, and SDI DATA to SDI D
Xlite: PWR IN+ to SDI-12 +12V, PWR IN G to SDI-12 GND, and SDI DATA to SDI-12 DATA
- Log into SETUP user and go into the setup tab. Add a sensor block, using the wizard, called SDI-12. Edit the properties of the block to address 0, measurement desired (M or C). If you want to see the shaft status, simply select the output 2 and wire a measure and log to it. Save the setup, exit and start recording. Refer to the [Sutron Xpert/Xlite Data Logger Operations Manual](#) if you do not know how to setup sensors.
- Once the system has measured the shaft encoder, use the VIEW SENSORS tab and select the SDIO-1 sensor. OPTIONALLY: Enter the SDI menu from VIEW SENSORS and issues a 0M! followed by a 0D0! to view data.

The Xpert/Xlite will now display the level readings from the shaft encoder.

SatlinkLogger

To use the shaft encoder with the SatlinkLogger, follow these steps:

- Connect the sensor PWR IN +, PWR IN G, and SDI DATA terminals to your Sutron SatlinkLogger SDI-12 port (PWR IN+ to SDI-12 +, PWR IN G to SDI-12 G, and SDI DATA to SDI-12 D).
- Use the SatlinkLogger communicator to enable a SDI-12 measurement with the command 0M! and SDI-12 parameter 1. If you want to see the shaft status, enable a second measurement with a 0M! and SDI-12 parameter 2 . Then send the setup to the SatlinkLogger. Refer to the [Sutron Satlink Logger Operations Manual](#) if you do not know how to configure measurements.
- Use the FORCE measurements button to get a reading from the sensor.

The SatlinkLogger will now display the level readings from the shaft encoder.

3. Cabling

The Chapter describes the wiring connections needed to use the various communications interfaces. For documentation of the individual pins of each connector, please refer to Appendix B.

SDI-12 Wiring

Only three wires are needed to use the shaft encoder SDI-12 interface. The following table contains the pin descriptions for the terminal block and ms connector:

-DT Terminal Block	-DM MS Connector	Description	Notes
1	B	Power IN +	Connect to Battery or data recorder +8 to +16
3	C	Power IN -	Connect to Ground
2	A	SDI-12 Data	Connect to data recorder SDI Data line

The MS connector is an Amphenol 97-3102A-14S-02P. The mating connector is a MS3106A-14S-2S and its equivalents. It is available from Sutron separately. It is also available with a 5 foot cable with stripped and tinned wires on the other end as Sutron Part number 6411-1299-1.

RS-232 Wiring

The communications parameters for RS-232 are:

- 1200 baud
- 7 data bits with even parity added as an eighth bit
- One stop bit
- Unit does not echo characters. Communications program must be set for local echo if you need to see what characters are typed.

The following table contains pin descriptions for the DB9F connector on the shaft encoder, with the corresponding RS-232 cable connections to PC. NOTE: A standard DB-9 male/female straight thru RS-232 cable should be able to plug into a PC's serial port and into the shaft encoder with these connections.

Name	DB9F Pin	IBM AT Connection (DB-9F cable)	IBM PC or any DTE Connection (DB-25-F cable)
TXD	2	2	3
RXD	3	3	2
DTR	4*	4	20
Ground	5	5	7

*Note, DTR must be asserted for the shaft encoder to transmit.

NOTE: For a quick bench test or configuring of the unit, operation off of the internal backup battery is possible. For long term use, the unit should have 12 Volts applied via the SDI-12 connector.

RS-485 (Differential SDI-12) Wiring

Four wires are needed to use the differential SDI-12 interface. Differential SDI-12 is not a defined standard. It is a low power modification of an RS-485 interface. It overcomes the cable limitation of SDI-12 since transmitted data is not referenced to the power supply ground. It does not utilize a power consuming DC termination resistor. It does have transient protection built in that raises the output impedance above the level that is normally encountered in RS-485 applications. The data signaling rate and protocol conform to SDI-12 standards. To use the RS-485 interface with non-SDI-12 equipment, refer to the SDI-12 specification for the protocol and timing details. The specification can be obtained at <http://www.sdi-12.org/>

The following table contains the connections for RS-485 wiring. Sutron's 8210 and XLITE are capable of using the RS-485 interface on the shaft encoder.

Terminal Block	Description	Notes
1	Power IN Positive	Battery or data logger +8 to +16 VDC
3	Power IN Ground	Battery or data logger ground
4	RS-485 B	+ Data (0 Volt idle state)
5	RS-485 A	- Data (5 Volt idle state)

4. Bench Setup and Operation

This chapter will cover the configuration of the encoder that can be performed on the bench, before going to the installation site. In general, follow these steps to set up the shaft encoder:

1. Install the internal battery in the shaft encoder (see Chapter 6). DO NOT leave the battery installed during storage or if the unit is not connected to main input power, since the battery is always on and will drain the battery.
2. Connect the Shaft Encoder to your device (see Chapter 3).
3. Rotate the shaft to see if the direction of rotation is set properly. If not, use the XDR command to set the direction of rotation (see page 15).
4. Set the wheel circumference and digits of precision as desired using the XWC command (see page 15). The default value is 1.000. Since the encoder multiplies the number of turns by this circumference, the display/output value will be in feet if you use a 1 foot wheel and a circumference of 1.0. Other common values for the wheel circumference are 375 (when using a 375 mm wheel) or 30.48 (when using a 1 foot wheel but want the display/output in cm). As you can see, the encoder takes on whatever units you use when entering the wheel circumference. If you change the circumference, be sure to also set the number of decimal places.
5. Set the current level using the XS or S0 command (see page 15). This sets the displayed value as well as the value returned by the M command. This is based the current direction of rotation and wheel circumference. Be sure to perform steps 3 and 4 before this step.

Shaft Encoder Startup

Turning on/off the Display

Whenever power is applied to the shaft encoder, the 8 digit by 2 line display will turn on and display the level as shown below. (Power is applied either when the internal battery is installed or, if no internal battery is installed, when external power is applied.) The display will time out and turn off after 5 minutes, to turn off the display before this, simply press the **DISPLAY** button. Once the display is off, simply press the **DISPLAY** button again to turn it back on.

Turning on the backlight

The display is equipped with a back light to assist in viewing under many different lighting conditions. To turn on the backlight, simply press and hold the **DISPLAY** button for 2 seconds when the display is on.

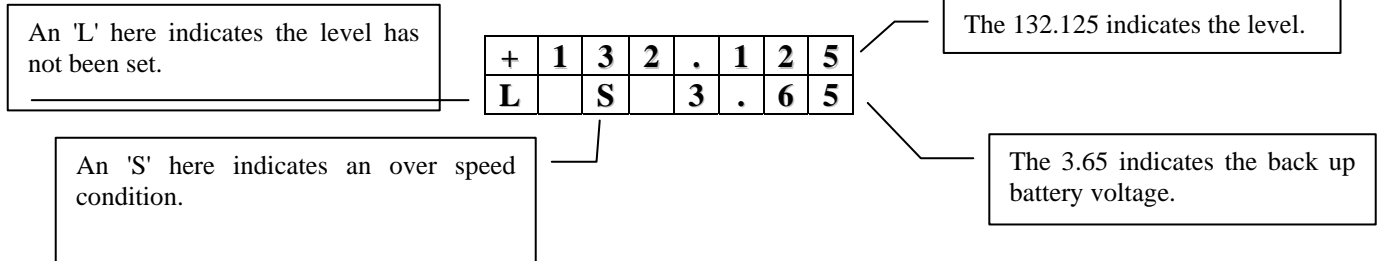
Adjusting the contrast

The display contrast can also be set to assist under different lighting conditions. To set the contrast, simply press and hold the **DISPLAY** button until contrast starts to change, continue holding the button until the contrast is at a readable level, and then release the button.

NOTE: If the back light was off, it will turn on. While the **DISPLAY** button is held down, the contrast will continuously vary from it's darkest to lightest settings, repeating until the display button is released.

Layout of the Display

The level shown on the display is the same as returned by the M command. Since the shaft encoder does not track the level when not powered up, the current level may not be correct. The display highlights this condition by placing an “L” in status line. The status line will also show the internal back-up battery voltage (this takes a few seconds to update) if one is installed, otherwise it will be a floating voltage number. If the shaft encoder detects an over speed condition, it will also place an 'S' in the status line next to the 'L'.



Factory default configuration

The shaft encoder comes from the factory with following default values:

- Address: 0
- Operating Mode: Automatic RS-232 mode enabled
- Wheel Circumference: 1.0
- Number of Decimal places in Result: 3
- Shaft direction: Clockwise as positive.
- Maximum Rotation speed: 2.5 Revolutions per Second
- Level Offset: 0
- Averaging time: 10 seconds
- Slope for M1 command: 0.533227

To issue commands to the shaft encoder via SDI-12 or RS-485, you will need to be connected to a data recorder, such as a Sutron 8200, 8210, 8400, 9210, Xpert or Satlink Logger which is capable of issuing standard and extended SDI-12 commands.

To issue commands to the shaft encoder via RS-232, you will need to connect it to an RS-232 terminal or to computer running terminal emulation (communications) software and to a power supply or battery. Follow the instructions in Section 3 in order to make these connections

RS-232 Automatic Reading Mode

The RS-232 port supports an automatic reading mode, i.e. when an RS-232 connection is made (DTR asserted), the unit will start reporting the level reading out the RS-232 port. The reported level will be same as provided by the measure command (M command). The output is the current level followed by a carriage return line feed sequence. For example:

0.002
0.003

By default, the value will have three decimal places, which can be changed (Refer [Setting Wheel Circumference](#) on how to change number of decimal places). The shaft encoder continues to report

the level once a second. If the shaft encoder receives a command, then the automatic reading mode will be disabled for that RS-232 session and the interaction with the unit will become command driven, just like SDI-12. It is possible to make the command driven mode the default. (Refer Setting Operating Mode for further details).

NOTE: If both an RS-232 connection and a SDI-12 connection are made to one shaft encoder, the SDI-12 takes priority. This means that during the time of a SDI-12 command, the unit will not accept commands from the RS-232 port. Once the unit has finish with the SDI-12 command, it will revert back to accepting RS-232 commands.

SDI-12 Commands (Overview)

The commands to set up and operate the shaft encoder are those defined by the SDI-12 specifications plus some extended commands defined by Sutron. The commands are in ASCII and all the replies use printable ASCII characters followed by <CR> <LF>. The case of the letters is important. An “A” is not the same as an “a”.

All commands have three components: the **device address**, the **command body**, and the **command termination**.

The **device address** is a single character with values 0 to 9, A to Z, and a to z. It is the first character of a command. It is usually the number 0 (the default address as shipped from the factory) if data recorder does not have multiple SDI devices connected to it.

The **command body** and the responses are shown as a combination of upper and lower case letters. The upper case letters are the fixed portions of the command and the lower case letters are the variables or values that are replaced by actual numbers. Values are entered in the form of a polarity sign (+ or -) followed by up to seven digits, including a decimal point.

The **command terminator** is an exclamation point (!). This works with both the SDI-12 and RS-232 interfaces. With RS-232, you have the additional option of terminating the command with a carriage return <CR> and/or line feed <LF> in place of the exclamation point.

NOTE: ALL SDI-12 COMMANDS ARE UPPER CASE.

The shaft encoder replies to all SDI-12 commands it supports. If the shaft encoder receives a command it does not support, no reply is made. The reply to a measurement command (M) will have one of two forms:

a0000 Where a is the address and the 0000 indicates that there is no further message from shaft encoder to send

Or

atttn
followed by
a Where a is the address, ttt is the amount of time, in seconds, the shaft encoder needs to make the measurement or process the command and n is the number of values that can be collected. As soon as the measurement is over, the sensor will also respond with its address (if ttt is not 000). This response is called a **service request**.

Setting the Address

The default SDI-12 address is 0.

If you are using the shaft encoder connected with other SDI-12 devices, you will need to change the shaft encoder address. Otherwise, skip this section. The address simply lets multiple devices share the same wiring. When the data recorder needs data from a particular sensor, it requests data using an address. Only the device with the matching address will reply. For convenience in setting up the unit when only one sensor is connected, the shaft encoder supports wildcard addresses of asterisk (*) and question mark (?).

In order to set the address by SDI-12 command or RS-232 command, no other SDI-12 devices connected to the system should be set to address 0 or to the desired Shaft Encoder address.

Hint: If you do not know the address of a particular shaft encoder, use the unknown address command to have the shaft encoder identify itself. There are 3 forms of the unknown address command:

?!
*!
*X?!

NOTE: In order for the unknown address command to work, there should be only be one shaft encoder connected.

The SDI-12 command for setting the shaft encoder's address is

<u>0An!</u>	Where 0 is the current address of the device, n is the new SDI-12 address (0 to 9, A to Z, a to z).
-------------	---

The shaft encoder will issue a Acknowledge Active response to verify the address set. If you do not get this message, try the command again

NOTE: The shaft encoder will not respond if the command is invalid.

As an example, the following command would set the shaft encoder address to 5:

0A5!

Subsequently, the address can be set to a different address, 9 for example, by the command:

5A9!

Verifying the Address and Operation

The shaft encoder will respond with an identifying message when it receives the *send identification* command, I. The format of the command is:

<u>a!</u>	Where a is the address for the shaft encoder.
-----------	---

The shaft encoder will reply with

a13 SUTRON mmmmmm1.0ssssssSvvv , where

a	SDI-12 address
13	supports SDI version 1.3 commands
SUTRON	manufacturer SUTRON
<u>mmmmmm</u>	model number – will return 0540-4 portion of 56-0540-400-Dx model number
1.0	hardware revision level
ssssss	sensor serial number
Svvv	the software revision

If you do not get a reply, check the address using ?! or *! with no other SDI device connected and make sure you use the proper address for the sensor.

Making a Measurement

There are four classes of measurement commands:

- M commands (Measurement Commands),
- C commands (Concurrent Measurement Commands),
- MC commands (Measurement commands with CRC-16) and
- CC commands (Concurrent Measurement Commands with CRC-16).

When collecting data from several SDI-12 sensors that have long measurement times, utilizing concurrent commands can shorten the complete data collection cycle. The data recorder can initiate the measurement on all the sensors and when each finishes, then collect the data from all of them. Since the measurement times overlap, the complete data collection cycle is shorter.

There is no advantage to the concurrent measurement C command when using one sensor. In that case, M commands should be used because the sensor issues a service request as soon as M command measurement is over, and therefore, the data recorder can get the data earlier without waiting for the whole time.

The measurement command classes with CRC-16 (MC and CC) offer additional data integrity checking over the non CRC-16 commands (M and C). The non CRC-16 commands offer data integrity checking in the form of parity and the SDI-12 command structure. The CRC-16 commands offer some additional data integrity through the addition of a CRC-16. Since the CRC-16 commands are brand new in SDI-12 version 1.3, not as many data recorders support them. In most applications, lack of this support on the part of the data recorder will not be missed since non CRC-16 SDI-12 commands still offer significant data integrity checking. If the data recorder supports CRC-16 commands, then it is recommended to use them when collecting data from this sensor in order to benefit from the increased noise immunity.

Example: (M command)

The format of the M command to the Shaft Encoder is:

<u>aM!</u>	<u>a</u> is the address character and <u>M</u> is the command to make a measurement
------------	--

Most data recorders will issue this command and automatically handle the reply to collect data. You can also issue the command yourself. In reply, the shaft encoder will respond with

<u>attt2</u>	indicating that after <u>ttt</u> seconds are allowed for the measurement, <u>2</u> values can be collected.
--------------	---

When the measurement is complete, the shaft encoder responds with a service request

<u>a</u>	where <u>a</u> is the address character
----------	---

Note that you still do not have any data from the shaft encoder. To request the data after a measurement,

<u>aD0!</u>	<u>a</u> is the address character and <u>D0</u> is the command to retrieve measured data. Note: the number zero follows D, not the letter O.
-------------	--

In this case, the shaft encoder will reply with two values in the format:

<u>avs</u>	<u>a</u> is the address, <u>v</u> is the data value having format of a polarity sign (+ or -) followed by up to seven digits including a decimal point, <u>s</u> indicates the shaft status (0=OK, 64=level not set, 128=over-speed detected, 192=level not set and overspeed) that is always preceded by a + sign
------------	--

The v Indicates the instantaneous level value based upon the current wheel circumference (XWC), direction of rotation (XDR), and last level set (XS or S0).

Example (C, MC and CC commands)

The C command is used to make a concurrent measurement. It operates identical to the M command except that the shaft encoder does not issue a service request when the measurement is complete.

The MC command is identical to the M command except that the shaft encoder adds a CRC to the end of the data.

The CC command is identical to the C command except that the shaft encoder adds a CRC to the end of the data.

Other Measurements

The SDI-12 standard allows for other measurement commands such as M1, M2 etc., other current measurement commands such as C1, C2, etc., other non-concurrent measurements with CRC-16 such as MC1, MC2, etc, and other concurrent measurement with CRC-16 such as CC1, CC2, etc. This unit maintains symmetry across all four classes of commands, that is, it returns the same

information to a C1 as it does to a M1 or a MC1 or a CC1. The shaft encoder supports the following optional measurement commands:

<u>aM1!</u> <u>aC1!</u> <u>aMC1!</u> <u>aCC1!</u>	Apply M1_Slope to convert from rotations to output value. Returns one value. (Note: Use XUP command to set the M1_Slope)
<u>aM2!</u> <u>aC2!</u> <u>aMC2!</u> <u>aCC2!</u>	Measure temperature (Celsius). Returns two values: first value is temperature in Celsius, and the second value is 0 indicating that the temperature value is in Celsius.
<u>aM3!</u> <u>aC3!</u> <u>aMC3!</u> <u>aCC3!</u>	Measure Contrast voltage and Battery voltage. Returns two values: first one is the Contrast voltage; second one is Battery voltage.
<u>aM4!</u> <u>aC4!</u> <u>aMC4!</u> <u>aCC4!</u>	Measure Average, Maximum and Minimum level. Returns three values: Average, Maximum and Minimum level over n seconds set by aXT+n! Command.
<u>aM5!</u> <u>aC5!</u> <u>aMC5!</u> <u>aCC5!</u>	Measure Battery voltage. Returns internal backup battery's voltage.
<u>aM6!</u> <u>aC6!</u> <u>aMC6!</u> <u>aCC6!</u>	Get time elapsed since reset. Returns three values: Hours, Minutes and Seconds.

Remember to issue the aD0! Command after the measurement is complete in order to retrieve the data.

Setting Operating Mode (RS-232 operation only)

The RS-232 port supports an automatic reading mode, i.e. when an RS-232 connection is made (DTR asserted), the unit will start reporting the level reading out the RS-232 port. The reported level will be same as provided by the measure command (M command). The output is the current level followed by a carriage return line feed sequence. For example:

0.002
0.003

The shaft encoder continues to report the level once a second. If the shaft encoder receives a command, then the automatic reading mode will be disabled for that RS-232 session and the interaction with the unit will become command driven, just like SDI-12.

The user can switch between these two operating modes: Automatic reading and Command driven as default on RS-232. The form of this command is:

aXOP+m!	Where a is the address character, XOP is the extended command to set the operating mode and <u>m</u> represents the operating mode.
---------	---

The valid values for m are:

- 0 RS-232 provides level reading (same as with M command) every second.
- 1 RS-232 command driven by same commands as SDI-12

For example,

0XOP+0! Will make the automatic level reading on RS-232 as default. Whenever RS-232 connection is made (DTR is asserted), the encoder will start sending level reading once a second.

0XOP+1! Will make command driven mode as default mode on RS-232. Whenever RS-232 connection is made (DTR is asserted), the encoder will not send any level reading on it's own, unless a command is issued.

NOTE: If both an RS-232 connection and a SDI-12 connection are made to one shaft encoder, the SDI-12 takes priority. This means that during the time of a SDI-12 command, the unit will not accept commands from the RS-232 port. Once the unit has finish with the SDI-12 command, it will revert to accepting RS-232 commands.

Setting the Wheel Circumference

The wheel circumference and number of decimal places to report the result are set together. The form of this command is:

aXWC+n+d!	Where a is the address character, XWC is the extended command to set the wheel circumference, n is the wheel circumference in desired units, d is the number of decimal places to report the result.
-----------	--

Since the encoder multiples the number of turns by this circumference, the display and output value will be in feet if you use a 1 foot wheel and a circumference of 1.0. The encoder takes on whatever units you use when entering the wheel circumference. If you change the circumference, be sure to also set the number of decimal places in the result.

For example with a 1 foot wheel:

- 0XWC+1+3! Will make the measurement report in feet with 3 decimal places,
- 0XWC+12+1! Will make the measurement report in inches with 1 decimal place,
- 0XWC+304.8+0! Will make the measurement report in millimeter with no fraction part,
- 0XWC+0.3048+3! Will make the measurement report in meters with 3 decimal places.

Using a 375 mm wheel the following are some of the possibilities:

- 0XWC+375+0! Will make the measurement report in mm with 0 decimal places,
- 0XWC+0.375+3! Will make the measurement report in meters with 3 decimal places
- 0XWC+1.230315+2! Will make the measurement report in feet with 2 decimal places

NOTE: Level must be set after using this command.

Setting the Direction of Rotation

By default, clockwise rotation is positive and counter-clockwise is negative. The SDI-12 command to change this is:

aXDR+d!	Where a is the address character, XDR is the extended command to set the direction of rotation specified by d.
---------	--

The valid values for d are:

- 0 Counter-clockwise as positive
- 1 Clockwise as positive

NOTE: Level must be set after using this command.

Setting the Maximum Rotation Speed

The current consumption increases with the increase in maximum supported rotation speed. Therefore, it is advisable to keep maximum rotation speed to what is actually required. By default, it is set to 2.5 revolutions per sec. The SDI-12 command to change this is:

aXRS+s!	a is the address character, XRS is an extended command to set the maximum rotation speed <u>s</u> revolutions per second.
---------	--

For example:

0XRS+3.4!

Will set maximum rotation speed to 3.4 revolutions per second. If the wheel rotates faster than 3.4 rotations in a second then a 'S' character will appear in the second line of the display to indicate an over speed condition. The over speed condition is cleared when the current level is set as described below.

On a standard unit, the maximum guaranteed rotation speed is 5.5. Setting the rotation speed higher than this can result in SDI-12 communications problems and other inappropriate behavior.

Setting the Level Using SDI Command

The level is set using one of the two commands below. The level must be entered in terms of the current measurement units (I.E. If the encoder is at the factory default of a 1 foot wheel, then the number entered is in terms of feet)

<u>aXSd!</u> or <u>aS0d!</u>	Where a is the address character, XS is the extended command and S0 (number 0) is the Sutron extended command, d is the level to set with it's polarity (+ or -)
------------------------------------	--

For example: 0XS+12.345!

Will set the level to +12.345

NOTE: A subsequent aD0! command will display the internal offset and not necessarily the user entered level.

Setting the Level Using Display Button (Version 1.2 onwards)

Note: This feature is not available in version 1.0 and 1.1 Before you can use this feature in version 1.2 and later, it must be enabled. Refer to the description for SDI command aXFS1! (aXFS0! to disable) on how to enable it. The version number is displayed at power-up on the 2nd line of encoders running versions 1.2 and later.

Invoking Set-Level Mode: Press and hold the Display button until you see “SetLevel” on the 2nd line of display. Releasing the button while “SetLevel” is displayed switches the display and button controls from normal mode to level setting mode. While in level setting mode, the cursor blinks on every character from left to right and the value of the character on cursor changes on every press of button or every half a second if your press and hold down the button. If there is no button activity for 4 seconds, the cursor shifts to next character on the right.

Entering Desired New Value: Enter the new value of level as the cursor goes from the 1st to 8th character on Line 1 of the Display. The level must be entered in terms of the current measurement units (i.e. if the encoder is at the factory default of a 1 foot wheel, then the number entered is in terms of feet). When the cursor times-out on the 8th character, the 2nd line on the display will change to “Save Y”. Press and release the button when the cursor is blinking on ‘Y’ to program this new value. If you do not want to program this new value, let the cursor time-out. In either case, level setting mode is exited and the display and button controls return to normal mode.

NOTE: The proper wheel circumference (XWC command) and direction of rotation (XDR command) must be set before setting the level.

Setting the Averaging Time

You can get Average, Maximum and Minimum level over the certain number of seconds called here as Averaging time. This Averaging time is user selectable (minimum 1 second and maximum 254 seconds). The factory default is 10 seconds. The form of this command is:

aXT+n!	Where a is the address character, XT is the extended command to set averaging time, n is the number of 1 second samples to average.
---------------	---

A subsequent aD0! Command will display the averaging time set. For Example,

0XT+20!

Will set the averaging time to 20 seconds for a shaft encoder at address 0. After this, whenever a aM4, aC4, aMC4 or aCC4 command is issued, the shaft encoder will take 20 readings of level at 1 second interval and will return the average, maximum and minimum level over these 20 seconds.

Reset the encoder to a Factory Default Configuration

The shaft encoder supports a reset to factory default command. The reset to factory defaults command provides a means to reset most user configurable parameters in a unit back to the factory defaults. If the previous history of a unit is not known, it is recommended that this command be issued before configuring the unit to ensure a known starting configuration.

aXFD!	Where a is the address character, XFD is the extended command to reset the unit to the factory default configuration. Note: The address is not changed.
-------	---

Note: It is recommended that the unit be powered down and back up after issuing this command.

A reset to factory defaults resets:

- Operating Mode: Automatic RS-232 mode enabled
- Wheel Circumference: 1.0
- Number of Decimal places in Result: 3
- Shaft direction: Clockwise as positive.
- Maximum Rotation speed: 2.5 Revolutions per Second
- Slope for M1 command: 0.533227

Items that are not reset:

- Address
- Level Offset
- Averaging time

Changing the slope for M1 readings

If there is a need for the unit to report a level in a different engineering unit than what is displayed (I.E. display inches, but log in centimeters), then the aM1! command can be used. The aXUP! Command will set the units to be reported back as follows:

M1 reading = Number of rotations x M1_slope

The M1_slope can be set using the form of the command as:

aXUP+n!	a is the address character, XUP is extended command to set M1_slope, n is the new M1_slope.
---------	---

6. Field Installation

Installing the Battery

The Shaft encoder uses a single AA size lithium battery for system power supply backup. A 3.6V lithium battery is included, but a 1.5V lithium battery will work. Alkaline batteries are not recommended due to their limited capacity at colder temperatures. The battery should not be installed during storage, as it is always on when installed. The battery is installed as follows:

1. Remove the battery cover by turning it one-half turn counterclockwise.
2. Install the battery with the positive (+) side facing the cover. NOTE: '+' polarity on battery and cover.
3. Place the battery cover back onto battery holder by turning it one-half turn clockwise.



Leveling the shaft encoder

Secure the encoder to a level platform with either three wood screws or the appropriate bolts, nuts, and lock washers. Three #10-32 mounting holes are provided for mounting feet or bolts, if additional leveling is required.

Installing the float wheel

Mount the wheel on the shaft and secure it by tightening the Allen screw(s) on the wheel. Attach the float and counter weight to the tape per the instructions provided. Set both the float and counter weight into the stilling well and mount the tape onto the wheel.

Wiring the shaft encoder to the data logger

Wire the shaft encoder to the data logger using either SDI-12, RS-232 or RS-485 as described in CHAPTER 3.

The chassis of the shaft encoder is electrically isolated from the ground of the SDI bus. This prevents differences in ground potential over long distance cable runs from interfering with the transmitted data. If additional grounding is needed, a 12 to 16-awg ground cable may be attached from the grounding bolt (using supplied wing nut and washers) to a good earth ground.

Checking the direction of rotation

Rotate the shaft to see if the direction of rotation is set properly (I.E. when float rises, level increases). If the level does not change as desired, either turn the tape around (put the float on the other side of the wheel) or use the XDR command to change the direction of rotation (see page 16).

Checking the float wheel size

If the wheel size has not been set, set the wheel circumference using the XWC command (see page 15). The default value is 1.000 (1 foot wheel with 3 right digits of precision). Other common values for the wheel circumference setting are:

- 12 - For a 1 foot wheel reading in units of inches
- 375 - For a 375 mm wheel
- 30.48 - For a 1 foot wheel with the display/reading in cm

The shaft encoder takes on whatever units are used when entering the wheel circumference.

NOTE: If this setting is changed, the number of decimal places to display should also be set (if omitted the default is 0 digits after the decimal point).

Setting the level

Once the unit is secured, and all of the parameters are configured, the level must be set. The level must be entered in terms of the current measurement units (I.E. If the encoder is at the factory default of a 1 foot wheel, then the number entered is in terms of feet).

Setting Level using SDI Command

The level is set using one of the two commands below.

<u>aXSd!</u> or <u>aS0d!</u>	Where a is the address character, XS is the extended command and S0 (number 0) is the Sutron extended command, d is the level to set with it's polarity (+ or -)
------------------------------------	--

For example: 0XS+12.345!

Will set the level to +12.345

NOTE: A subsequent aD0! command will display the internal offset and not necessarily the user entered level.

Setting the Level Using Display Button (Version 1.2 onwards)

Note: This feature is not available in version 1.0 and 1.1 Before you can use this feature in version 1.2 and later, it should be in enabled state. Refer description for SDI command aXFS1! on how to enable it (aXFS0! to disable). Version number is displayed at power-up on 2nd line of encoders running versions 1.2 and later.

Invoking Set-Level Mode: Press and hold the Display button until you see "SetLevel" on the 2nd line of display. Releasing the button while "SetLevel" is being displayed switches display and button controls from normal mode to level setting mode. While in level setting mode, cursor blinks on every character from left to right and the value of character on cursor changes on every press of button or every half a second if your press and hold down the button. If there is no button activity for 4 seconds, the cursor shifts to next character on the right.

Entering Desired New Value: Enter the new value of level as cursor goes from 1st to 8th character on Line 1 of Display. When cursor times-out on 8th character, the 2nd line on the display will change to "Save Y". Press and release the button when cursor is blinking on 'Y' to program this new value. If you do not want to program this new value, let cursor time-out. In either case, level setting mode is exited and the display and button controls return to normal mode.

Before leaving the installation site

Check that the logger is programmed to take readings from the shaft encoder with the proper measurement command (Typically M or C.). Then try to obtain live readings from the shaft encoder to ensure proper communication between the two units.

7. Troubleshooting and Maintenance

Troubleshooting

The following checklist will help in troubleshooting problems:

Problem	Possible Cause	Corrective Measure
No display	Display timed out	Press & Release the display key. The display will time out 5 minutes after the key is pressed.
	Contrast adjustment	Press and hold the display key down. You should see the backlight turning on/off after 1 second, and 3-7 seconds after this, the contrast repeatedly varying from light to dark to light. Release the key when you find the contrast to be fine.
	No contrast voltage	Read Contrast voltage, it should be between -2.0 and 1.0 volts. If not, then try adjusting contrast.
No Data	No Power	Check fuse in the data recorder and power at sensor. No customer replaceable fuse is installed in the sensor itself.
	Wrong address requested	Make sure the Data recorder is set up to request data at the proper address.
	Wrong address set in sensor	Use the identify command (0I! if sensor's address is 0) to make sure the sensor is responding to the proper address. If not, then double-check the internal address. For this, remove, all other sensors, issue the ?! command and make sure that response matches with the address at which data is requested.
	Alphabets in command are in wrong case	All shaft encoder commands are in uppercase. Make sure that none of the commands are in lowercase.
	Faulty Wiring	Check all wiring and terminations. Try communication using other interfaces. The shaft encoder supports SDI-12, RS-485 and RS-232 interfaces. If problem is with RS-232 interface only, make sure that Transmit Data and Receive Data are not reversed. With RS-485, make sure that the data lines are not reversed.
Garbled Data	Multiple Sensors set to same address	Check address settings of all SDI sensors. Remove all other sensors from the recorder and add them one at a time. Communication is defined to be 1200 Baud, Even Parity, 7 Data bits, 1 stop bit.
	Wild Card address may have been used	Remove all other sensors from the recorder and try again.

Erroneous Level Reporting	Level never set	Check if there is letter 'L' displayed on the left bottom corner of LCD display. If so, then it means that the current level has never been set, or the sensor was reset after the level was set.
	Level set incorrectly	Use XS! Command to see the offset programmed in the shaft encoder. You may need to validate that.
	Over-speeding	Check if 'S' is displayed in the 3 rd place of 2 nd line of display. If so, you may need to increase maximum over-speed using XRS+s! command and then set the level with XS! Command.
Erroneous M1 reporting	Wrong M1_slope	Use XUP! command to read the M1_slope set in the shaft encoder. Change the value of the slope if it is incorrect.
Erroneous reporting of Average, Maximum and Minimum level	Averaging time too short	Increase Averaging time using XT+n! command.
'L' appears on display	System reset	Check back up battery. If it appears after setting the level, it means the shaft encoder has been reset. Use the M6 command to find out when it was reset.
'S' appears on display	Over-speeding	Increase maximum over-speed using XRS+s! command.

CAUTION: There are no user-serviced parts or adjustments in the shaft encoder. If there is a problem with the encoder, please notify Sutron Customer Service at (703) 406-2800. Only factory-trained personnel with specialized tools can remove the microprocessor without damaging the unit and the processor.

Maintenance

The 56-0540 SDI-12 Shaft Encoder is designed to operate for extended periods of time with very little or no maintenance required. If a site visit is needed for any reason, it is a good idea to perform a routine maintenance check of the encoder and any other devices which may be in operation. Some easy to follow guidelines are listed below.

1. Perform a visual inspection of the unit. Note any abnormalities such as external oxidation, rust, or any defects caused by mechanical failure.
2. Check the wiring to make sure it is not corroded, frayed, or loose.
3. Rotate the shaft and verify there is no signs of scraping, rubbing, or misalignment of the internal wheel and external pulley. If realignment of the pulley is deemed necessary, loosen the pulley to allow movement, realign, and then retighten the pulley. Also, verify that float and counter weight move freely.
4. Check the internal battery voltage either through the display or by using the SDI command M5.

Voltage	Indication
> 3.7 volts	Verify that a battery is actually installed.
3.2 to 3.7	3.6 V lithium battery is installed
1.8 to 3.2	Either no battery installed or 3.6V lithium needs replaced.
1.2 to 1.7	1.5 V battery is installed
< 1.1 volts	Battery needs replaced.

5. Depress the read button to illuminate the display and then rotate the shaft clockwise and counterclockwise while observing the displayed value. Verify the encoder counts up and down appropriately.
6. Interrogate the encoder from the data logger to verify proper communication. Send several SDI-12 commands and verify that the encoder responds favorably.
7. Check the current level against physical measurement. Use the Set Level command to make any adjustments necessary.

8. Specifications for Shaft Encoder

Input Voltage	8 to 16 VDC over voltage and reverse voltage protected
Power Consumption	< 2.5 mA @ 12 VDC and 2.5 rev/sec
Starting Torque	< 0.25 inch-ounce
Shaft Diameter	5/16 inch with both threads and a flat
Rotation Resolution	400 count per revolution
Counter resolution	32 bit
Reported resolution	User selectable
Range	7 decimal digits (examples: ±99999.99 or ±9999.999)
Display	2 line, 8 character per line with backlight
Backup Battery	AA size, 1.5V or 3.6V accepted
Bearing Supports	Double bearing arrangement supports up to 10 lb. shaft load
Supported Wheels	User specifies wheel size - no required circumference
Support Units	User specified
Rotation Speed	User specified - factory default 2.5 rev/s
Maximum Rotation Speed	5.5 rev/s
Temperature Range	-40°C to +60°C (Display viewable -20°C to +60°C)
Communication Interfaces	SDI-12, RS-232, SDI-12 protocol over RS-485 (on -DT unit)
SDI-12 Support	V1.3 - will work with V1.0, V1.1, V1.2, and V1.3 data loggers

Ordering Information

Part Number	Description
56-0540-400-DT	SDI 12 Shaft Encoder, 400 count resolution with display and terminal strip. Supports RS-232, SDI-12, SDI-12 over RS-485.
56-0540-400-DM	SDI 12 Shaft Encoder, 400 count resolution with display and MS connector. Supports RS-232 and SDI-12.

Appendix A -- Command Reference

This chapter documents the commands supported by the shaft encoder. The commands are listed in alphabetical order within a section.

Shaft Encoder Basic SDI-12 Commands

	Command Description	Command Syntax	Shaft encoder response (underlined) "a" represents the single-character address
	Acknowledge active	<u>a!</u>	<u>A</u> Where a is the address of shaft encoder
?	Request Address (Also see X? command)	<u>?!</u>	<u>A</u> Indicating that the current address is <u>a</u> . Note: shaft encoder should be the only sensor on the SDI-12 bus when this command is given, otherwise this will cause response from all SDI devices resulting in communications collision.
Ab	Set SDI-12 address	<u>aAb!</u>	<u>b</u> Indicating that the new address is b.
C	Request Concurrent Level Measurement	<u>aC!</u>	<u>a00102</u> Indicating that 2 values can be collected after 1 second.
		<u>aD0!</u>	<u>avs</u> Where v is the signed value of instantaneous level and s is status of shaft: s = 0 Okay s = 64 Level has never been Set s = 128 Over-speed s = 192 Level has never been set and Over-speed
C1	Request Concurrent Level Measurement	<u>aC1!</u>	<u>a00101</u> Indicating that 1 value can be collected after 1 second.
		<u>aD0!</u>	<u>ap</u> Where p is the number of turns * user set slope (See XUP command to set slope)
C2	Request Concurrent Temperature Measurement	<u>aC2!</u>	<u>a00102</u> Indicating that 2 values can be collected after 1 second.
		<u>aD0!</u>	<u>atu</u> Where t is the temperature in Celsius and u is 0 (indicating it's a Celsius value)
C3	Request Concurrent measurement of Display-contrast voltage and internal Battery voltage	<u>aC3!</u>	<u>a00102</u> Indicating that 2 values can be collected after 1 second.
		<u>aD0!</u>	<u>acb</u> Where c is the signed value of contrast voltage applied to display, b is internal battery voltage. Both results are in volts.

C4	Request Concurrent measurement of Average, Maximum and Minimum level	<u>aC4!</u>	<u>attt03</u> Indicating that 3 values can be collected after ttt(Averaging time + 1) seconds .
		<u>aD0!</u>	<u>xyz</u> Where x is the average level, y is the maximum and z is the minimum level over the past averaging time.
C5	Request Concurrent measurement of internal Battery Voltage	<u>aC5!</u>	<u>a00101</u> Indicating that 1 value can be collected after 1 second.
		<u>aD0!</u>	<u>ab</u> Where b is the battery voltage in volts
C6	Request time elapsed since last system reset	<u>aC6!</u>	<u>a00103</u> Indicating that 3 values can be collected after 1 second.
		<u>aD0!</u>	<u>ahms</u> Where h, m and s are hours, minute and seconds, respectively.
CC	Request Concurrent Level Measurement, with CRC-16	<u>aCC!</u>	<u>a00102</u> Indicating that 2 values can be collected after 1 second.
		<u>aD0!</u>	<u>avsC</u> Where v is the signed value of instantaneous level, s is status of shaft: s = 0 Okay s = 64 Level has never been Set s = 128 Over-speed s = 192 Level has never been set and Over-speed, C is the 3 character CRC.
CC1	Request Concurrent Level Measurement with CRC-16	<u>aCC1!</u>	<u>a00101</u> Indicating that 1 value can be collected after 1 second.
		<u>aD0!</u>	<u>apC</u> Where p is the number of turns * user set slope, and C is the 3 character CRC (See XUP command to set slope)
CC2	Request Concurrent Temperature Measurement, with CRC-16	<u>aCC2!</u>	<u>a00102</u> Indicating that 2 values can be collected after 1 second.
		<u>aD0!</u>	<u>atuC</u> Where t is the temperature in Celsius, u is 0 (indicating it's a Celsius value) , and C is the 3 character CRC.
CC3	Request Concurrent measurement of Display-contrast voltage and internal Battery voltage, with CRC-16	<u>aCC3!</u>	<u>a00102</u> Indicating that 2 values can be collected after 1 second.
		<u>aD0!</u>	<u>acbC</u> Where c is the signed value of contrast voltage applied to display, b is internal battery voltage, and C is the 3 character CRC. Both results are in volts.
CC4	Request Concurrent measurement of Average, Maximum and Minimum level, with CRC-16	<u>aCC4!</u>	<u>attt03</u> Indicating that 3 values can be collected after ttt(Averaging time + 1) seconds .
		<u>aD0!</u>	<u>xyzC</u> Where x is the average level, y is the maximum level, z is the minimum level over the past averaging time, and C is the 3 character CRC.

CC5	Request Concurrent measurement of internal Battery Voltage, with CRC-16	<u>aCC5!</u>	<u>a00101</u> Indicating that 1 value can be collected after 1 second.
		<u>aD0!</u>	<u>abC</u> Where b is the battery voltage in volts, and C is the 3 character CRC
CC6	Request time elapsed since last system reset, with CRC-16	<u>aCC6!</u>	<u>a00103</u> Indicating that 3 values can be collected after 1 second.
		<u>aD0!</u>	<u>ahmsC</u> Where h, m and s are hours, minute and seconds, respectively; and C is the 3 character CRC.
D0	Request Data (NOTE: This command is only issued after a measurement command. It should not be issued until the measurement time has expired or a service request has been received)	<u>aD0!</u>	<u>av</u> v contains the previously-requested measurement values. Example: 0 + 10.23 + 0 If the above example was received and the previous measurement command was an M, it would indicate that the water level is at 10.23 feet, and 1 means there is no shaft error. NOTE: If the address is returned with no data values, this indicates that there is no data available. Either a measurement command was not issued, or the command was aborted by sending a new command before the measurement time expired, or a service request was received.
I	Send Identification	<u>aI!</u>	<u>a13 SUTRON 0540-41.0sssssssSvvv</u> <u>13</u> supports SDI version 1.3 commands <u>SUTRON</u> manufacturer <u>0540-4</u> model number <u>1.0</u> hardware revision level <u>sssssss</u> the sensor serial number <u>Svvv</u> the software revision
M	Request Level Measurement	<u>aM!</u>	<u>a0012</u> Indicating that 2 values can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>avs</u> Where v is the signed value of instantaneous level and s is status of shaft: s = 0 Okay s = 64 Level has never been Set s = 128 Over-speed s = 192 Level has never been set and Over-speed

M1	Request Level Measurement	<u>aM1!</u>	<u>a0011</u> Indicating that 1 value can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>ap</u> Where p is the number turns * M1_slope (set by XUP command).
M2	Request Temperature Measurement	<u>aM2!</u>	<u>a0012</u> Indicating that 2 values can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>atu</u> Where t is the temperature in Celsius and u is 0 (indicating it's a Celsius value)
M3	Request measurement of Display-contrast voltage and internal Battery voltage	<u>aM3!</u>	<u>a0012</u> Indicating that 2 values can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>acb</u> Where c is the signed value of contrast voltage applied to display, b is internal battery voltage. Both results are in volts.
M4	Request measurement of Average, Maximum and Minimum level	<u>aM4!</u>	<u>attt3</u> Indicating that 3 values can be collected after ttt(Averaging time + 1) seconds. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> where a is the address of shaft encoder.
		<u>aD0!</u>	<u>axyz</u> Where x is the average level, y is the maximum and z is the minimum level over the past averaging time.
M5	Request measurement of internal Battery Voltage	<u>aM5!</u>	<u>a0011</u> Indicating that 1 value can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>ab</u> Where b is the battery voltage in volts

M6	Request time elapsed since last system reset	<u>aM6!</u>	<u>a0013</u> Indicating that 3 values can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>ahms</u> Where h, m and s are hours, minute and seconds, respectively.
MC	Request Level Measurement, with CRC-16	<u>aMC!</u>	<u>a0012</u> Indicating that 2 values can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>avsC</u> Where v is the signed value of instantaneous level, s is status of shaft: s = 0 Okay s = 64 Level has never been Set s = 128 Over-speed s = 192 Level has never been set and Over-speed C is the 3 character CRC.
MC1	Request Level Measurement with CRC-16	<u>aMC1!</u>	<u>a0011</u> indicating that 1 value can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>apC</u> Where p is the number of turns * user set slope and C is the 3 character CRC (See XUP command to set slope)
MC2	Request Temperature Measurement, with CRC-16	<u>aMC2!</u>	<u>a0012</u> Indicating that 2 values can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>atuC</u> Where t is the temperature in Celsius, u is 0 (indicating it's a Celsius value) , and C is the 3 character CRC.

MC3	Request measurement of Display-contrast voltage and internal Battery voltage, with CRC-16	<u>aMC3!</u>	<u>a0012</u> Indicating that 2 values can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>acbC</u> Where c is the signed value of contrast voltage applied to display, b is internal battery voltage, and C is the 3 character CRC. Both results are in volts.
MC4	Request measurement of Average, Maximum and Minimum level, with CRC-16	<u>aMC4!</u>	<u>attt3</u> Indicating that 3 values can be collected after ttt(Averaging time + 1) seconds. After the measurement is complete and before ttt seconds, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>axyzC</u> Where x is the average level, y is the maximum level, z is the minimum level over the past averaging time, and C is the 3 character CRC.
MC5	Request measurement of internal Battery Voltage, with CRC-16	<u>aMC5!</u>	<u>a0011</u> Indicating that 1 value can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>abC</u> Where b is the battery voltage in volts, and C is the 3 character CRC
MC6	Request time elapsed since last system reset, with CRC-16	<u>aMC6!</u>	<u>a0013</u> Indicating that 3 values can be collected after 1 second. After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>ahmsC</u> Where h, m and s are hours, minute and seconds, respectively; and C is the 3 character CRC.

V	Initiate Verify sequence	<u>aV!</u>	<u>a0055</u> Indicating that the command will complete in 5 seconds and 5 values can be collected after that. After the measurement is complete and before 5 seconds, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>arespu</u> Where r is the ROM checksum, e is the EEROM checksum, s is a reserved field, p is the number of resets, and u is the number of unexpected interrupts.

Shaft Encoder Extended Commands

	Command Description	Command Syntax	Shaft encoder response (underlined) "a" represents the single-character address
X?	Request Unknown Address	<u>*X?!</u>	<u>a</u> Indicating that the current address is <u>a</u> . Note: shaft encoder should be the only sensor on the SDI-12 bus when this command is given, otherwise this will cause response from all SDI devices resulting in communications collision.
aXB!	Measure break time	<u>aXB!</u> <i>MAY ONLY BE ISSUED OVER RS-232 INTEFACE</i>	<u>a0012</u> Indicating that 2 values can be collected after 1 second
		<u>aD0!</u>	<u>a+d+r</u> Where d is the break detect time and r is the break reset time
XDR	Set and/or Read Direction of Rotation	<u>aXDR!</u> Read current direction <u>aXDR+d!</u> Set and Read direction Values for d: 0 Counter-clockwise as positive. 1 Clockwise as positive	<u>a0011</u> Indicating that 1 value can be collected after 1 second. After the new direction of rotation is set, the shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>a+d</u> Where d is the direction of rotation (0 or 1)

XFD	Reset to Factory defaults	<p>aXFD!</p> <p>This command resets most user configurable configuration items back to the factory defaults. It does not reset the address.</p> <p>Note: It is recommended that the unit be powered down and back up after use of this command.</p>	<p><u>a0031</u></p> <p>Indicating that 1 value can be collected after 3 seconds.</p> <p>After all the parameters are set to factory defaults in the EEPROM, Shaft encoder sends service request</p> <p><u>a</u></p> <p>Where a is the address of shaft encoder.</p>
		<p><u>aD0!</u></p>	<p><u>a+m</u></p> <p>Where m is the operating mode</p>
XFS	Enable/Disable feature of Level Setting using Display Button	<p>aXFS!</p> <p>Read current state</p> <p>aXFS1!</p> <p>Enable</p> <p>aXFS0!</p> <p>Disable</p> <p>(Factory default condition)</p>	<p><u>a0011</u></p> <p>Indicating that 1 value can be collected after 1 second.</p> <p>After the new mode is written into EEPROM, Shaft encoder sends service request</p> <p><u>a</u></p> <p>Where a is the address of shaft encoder.</p>
		<p><u>aD0!</u></p>	<p><u>a+m</u></p> <p>Where m is the mode: 0 or 1</p>
XOP	Set and/or Read Operating Mode	<p>aXOP!</p> <p>Read current mode</p> <p>aXOP+m!</p> <p>Set and Read mode</p> <p>Values for m:</p> <p>0 Factory default condition which starts reporting level readings when an RS-232 connection is made.</p> <p>1 Disable automatic reading mode for RS-232</p>	<p><u>a0011</u></p> <p>Indicating that 1 value can be collected after 1 second.</p> <p>After the new mode is written into EEPROM, Shaft encoder sends service request</p> <p><u>a</u></p> <p>Where a is the address of shaft encoder.</p>
		<p><u>aD0!</u></p>	<p><u>a+m</u></p> <p>Where m is the mode: 0 or 1</p>
XRS	Set and/or Read maximum rotation speed in revolutions per second	<p>aXRS!</p> <p>Read current speed</p> <p>aXRS+s!</p> <p>Set and Read speed where s is the desired max speed in revolutions per second. For example,</p> <p>0XRS+3.4!</p>	<p><u>a0011</u></p> <p>Indicating that 1 value can be collected after 1 second.</p> <p>After the new speed is set, Shaft encoder sends service request</p> <p><u>a</u></p> <p>Where a is the address of shaft encoder.</p>
		<p><u>aD0!</u></p>	<p><u>a+r</u></p> <p>Where r is the maximum speed supported</p>

XS	Set level and/or Read Level offset	aXS! Read internal level offset	<u>a0011</u> Indicating that 1 value can be collected after 1 second.
		aXSd! Set level and Read level offset Where d is the level with it's polarity.	After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>ad</u> Where d is the level offset with it's polarity
XT	Set and/or Read Averaging time	aXT! Read Averaging time	<u>a0011</u> Indicating that 1 value can be collected after 1 second.
		aXT+n! Set and Read averaging time where n is the number of 1-second-samples for the average/maximum and minimum.	After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>a+t</u> Where t is the averaging time
XUP	Set and/or Read M1_slope (Used by M1, MC1, C1, and CC1 commands.)	aXUP! Read current value	<u>a0011</u> Indicating that 1 value can be collected after 1 second.
		aXUP+v! Set and Read value where v is the new constant.	After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>ac</u> Where c the constant with it's polarity
XWC	Set and/or Read Wheel Circumference	aXWC! Read wheel circumference	<u>a0012</u> Indicating that 2 values can be collected after 1 second.
		aXWC+n+d! Set and Read wheel circumference where n is the Wheel circumference in desired units, d is number of decimal places.	After the measurement is complete and before 1 second, Shaft encoder sends service request <u>a</u> Where a is the address of shaft encoder.
		<u>aD0!</u>	<u>a+w+d</u> Where w is the wheel circumference and d is the number of decimal places

Appendix B – Connector Pins

DB9 Connector

The shaft encoder comes with a DB9F connector for connection to RS-232 devices. The DB9F is not used in SDI-12 and RS-485 systems. The wiring of the connector is as follows:

DB9F Pin	Name	Notes
1	N/C	No Connection
2	TXD	Data from shaft encoder to Data-Logger
3	RXD	Data from Data-Logger to the shaft encoder
4	DTR	Must be by Data-Logger for RS-232 communication
5	Ground	
6	N/C	No Connection
7	RTS	Request to Send, asserted by Data-Logger
8	CTS	Clear to Send, asserted by shaft encoder
9	Battery	Power +12 volts (not necessary if power provided via SDI-12 connector).

Terminal Block (-DT & -DTR models)

The –DT model shaft encoder has a terminal strip that provides connections for SDI-12 and RS-485 systems. The following table describes the connections of the terminal block.

Terminal Block	Description	Notes
1	Power IN +	+8 to +16 VDC power or positive battery terminal
3	Power IN -	Ground or negative battery terminal
2	SDI-12 Data	SDI-12 data line
4	RS-485 B	+ Data (0 Volt idle state)
5	RS-485 A	– Data (5 Volt idle state)

MIL Connector (-DM)

The –DM model shaft encoder has a 4 pin MS connector that provides the SDI-12 connections. This option does not provide connections for RS-485. The MS connector is an Amphenol 97-3102A-14S-02P. The mating connector is a MS3106A-14S-2S and its equivalents. It is available from Sutron separately. It is also available with a 5 foot cable with stripped and tinned wires on the other end as Sutron Part number 6411-1299-1. The following table describes the connections of the MS connector.

Mil Connector	Description	Notes
A	SDI-12 Data	SDI-12 data line
B	Power IN +	+8 to +16 VDC power or positive battery terminal
C	Power IN -	Ground or negative battery terminal
D	N/C	Not used

Appendix C -- SDI-12 with the Sutron 8200, 8200A, and 8210

Entering Extended Commands for Configuration Purposes

The Sutron 8200 family of data recorders supports the SDI-12 transparent mode. This allows the user to issue commands to the sensor via the data recorder.

From the Front Panel

Go down the menu tree till you come to:
INSPECT SYSTEM
Go right and then down until you come to:
Enter SDI-12 Cmd
Press SET and then the unit will prompt you with:
Cmd:

At this point enter the command you wish issued over the SDI-12 bus. The command is entered via the arrow keys. Remember that the address is always the first character of the command. The 8200 will append the ! to the end of the command for you. When you have finished entering the command press SET and the 8200 will send the command and display the response to the command.

From a PC connected to the RS-232 port

From the main menu select:

I - Inspect System

From the inspect system menu select:

E - Enter SDI-12 Commands

At this point you will be prompted to enter the command. Enter the command beginning with the unit's address and ending with an exclamation point (!). Do not forget the exclamation point. After entering the command, press ENTER to send the command out over the SDI-12 bus. The 8200 will then display the response to the command.

Logging data from the M1 or M2 commands or from addresses above 9

Beginning with version 3.3 of the software for the 8200 family, SDI-12 sensors can be renamed to allow any SDI-12 address or measurement number to be specified. To remap an SDI-12 sensor from its default address and parameter number you can use the form: SENSOR7a_p where SENSOR7 is the name you wish to give the sensor (up to 7 characters), a is the address of the sensor "0" through "~", and p is the parameter number "1" through "9".

EXAMPLE:

airtempA_1
would read parameter 1 from the SDI-12 device at address "A".

If you wish to use a measurement command other than the default aM!, then you can use the form: SENS5a_pMm where SENS5 is the name you wish to give the sensor (up to 5 characters), a is the address of the sensor "0" through "~", p is the parameter number "1" through "9", and m is the measurement command to use.

EXAMPLE:

stage0_1M3
would use measurement command M3 to read parameter 1 from the SDI-12 device at address 0.

Another feature is that you can define multiple sensors for the same SDI-12 parameter which will allow you to define separate slopes, offsets, and other processing for the same parameter.

Logging data with multiple data recorders

Setup two Sutron data recorders with one Shaft Encoder

This setup allows for a shaft encoder sensor to be logged in two Sutron data recorders at the same time.

Connect the SDI-12 ground line to both data recorders and the Shaft Encoder

Connect the SDI-12 Data line to both data recorders and the Shaft Encoder

Connect the SDI-12 power line from one Data recorder to the Shaft Encoder

NOTE: Measurement time in one of the data loggers should be offset by at least 30 seconds with respect to the other data logger.

Setup two Sutron Data Recorders with two Shaft Encoders

This setup allows for two shaft encoder sensors to be logged in two Sutron Data recorders at the same time.

Connect the SDI-12 ground line to both data recorders and both Shaft Encoders

Connect the SDI-12 Data line to both data recorders and both Shaft Encoders

Connect the SDI-12 power line from one Data recorder to one Shaft Encoder

Connect the SDI-12 power line from the other Data recorder to the other Shaft Encoder

- Sensors must have different addresses.
- Measurement time in one of the data loggers should be offset by 30 seconds with respect to the other datalogger.

Appendix D – RS-232 setup for use with the shaft encoder

Connect serial cable to DB-9 connector on shaft encoder.

Note: External power must be supplied to the shaft encoder. It can not be powered off of the computers RS-232 port. External power can be supplied via the SDI-12 connector. It is possible to supply power via the DB-9 connector but it would require a custom cable. Refer to the RS-232 wiring section of the manual for full details.

Communications parameters should be 1200 E71.

To see the characters you type, the communications program must be configured to echo the characters.

Additional PROCOMM notes

Terminal emulation should be VT-100 or equivalent.

To be able to see the commands you type, make the following changes to the default setup:

- Change Duplex to HALF: Alt + S, then select 2 for Terminal Setup and change option 2 to HALF.
- Change Echo to YES: Alt + S, then select 6 for ASCII Transfer Setup and change option 1 to YES.

Procomm Plus requires an additional change in the setup.

<ALT-S> , setup menu. Now proceed to PROTOCOL OPTIONS, then to GENERAL OPTIONS. Set selection C to "NO". This is the "Abort transfer if CD lost". This needs to be NO!!!

Appendix E -- Sutron Customer Service Policy

CUSTOMER SERVICE POLICY

Dear Customer:

Thank you for making the important decision to purchase Sutron equipment. All Sutron equipment is manufactured and tested to the highest quality standards as set by Sutron's Quality Assurance Department. Our Customer Service Representatives have years of experience with equipment, systems, and services. They are electronic technicians with field and applications experience, not just with a technical background.

Customer Phone Support

Customer Service Representatives routinely handle a wide variety of questions every day. If questions arise, please feel free to contact me or one of the Customer Service Representatives. We are available from 8:00 am to 5:00 pm Monday through Friday and will be happy to take your call.

We can answer most sensor and interface questions on the first call. If we cannot quickly answer a question on an interface, we will work with you until we find a solution.

Sometimes a problem is application related. Although we pride ourselves on handling 95% of application related questions over the phone, we maintain constant contact with our Integrated Systems Division and Engineering Division for additional assistance.

Introductory Training

Training is an important part of the Sutron Customer Service philosophy. The Sutron training policy is simple---If you buy Sutron equipment, you get Sutron training! Without the proper training, you cannot take advantage of the benefits and advantages that Sutron equipment provides. We often supply on-site introductory training at your facility for no charge. You provide the classroom, students, equipment, and coffee---we'll provide the instructor.

On-Site Visits

Of course not all problems can be fixed over the phone. Sometimes a customer needs an on-site technician to identify site related problems or troubleshoot a network. Sutron can provide these services at a reasonable cost. Call for details. If you would like to learn more about Sutron products email sales@sutron.com

Thanks again for your order,

Paul Delisi
Customer Service Manager
Sutron Corporation

APPENDIX F Commercial Warranty

SUTRON MANUFACTURED EQUIPMENT

THE SUTRON CORPORATION WARRANTS that the equipment manufactured by its manufacturing division shall conform to applicable specifications and shall remain free from defects in workmanship and material for a period ending two years from the date of shipment from Sutron's plant.

Sutron's obligation under this Warranty shall be limited to repair at the factory (21300 Ridgetop Circle, Sterling, VA 20166), or at its option, replacement of defective product. In no event shall Sutron be responsible for incidental or consequential damages, whether or not foreseeable or whether or not Sutron has knowledge of the possibility of such damages. This warranty shall not apply to products that have been damaged through negligence, accident, misuse, or acts of nature such as floods, fires, earthquakes, lightning strikes, etc.

Sutron's liability, whether in contract or in tort, arising out of warranties or representations, instructions or defects from any cause, shall be limited exclusively to repair or replacement parts under the aforesaid conditions.

Sutron requires the return of the defective electronic products or parts to the factory to establish claim under this warranty. The customer shall prepay transportation charges to the factory. Sutron shall pay transportation for the return of the repaired equipment to the customer when the validity of the damage claim has been established. Otherwise, Sutron will prepay shipment and bill the customer. All shipments shall be accomplished by best-way surface freight. Sutron shall in no event assume any responsibility for repairs or alterations made other than by Sutron. Any products repaired or replaced under this warranty will be warranted for the balance of the warranty period or for a period of 90 days from the repair shipment date, whichever is greater. Products repaired at cost will be warranted for 90 days from the date of shipment.

NON-SUTRON MANUFACTURED EQUIPMENT

The above Warranty applies only to products manufactured by Sutron. Equipment provided, but not manufactured by Sutron, is warranted and will be repaired to the extent of and according to the current terms and conditions of the respective equipment manufacturers.

REPAIR AND RETURN POLICY

Sutron maintains a repair department at the factory, 21300 Ridgetop Circle, Sterling, VA 20166. Turn around time normally ranges from 10-30 days after Sutron receives equipment for repair. **Call Customer Service at (703) 406-2800 for a Return Material Authorization (RMA) number.** Return the defective equipment to the factory, transportation charges paid.

EXTENDED WARRANTY AND ON-SITE MAINTENANCE

Extended warranty and on-site maintenance contracts are available. Price quotations may be obtained from Sutron customer service representatives.