SDI-12
Radar Water Level Sensor

Document ID: 32602
# Revision History

<table>
<thead>
<tr>
<th>Version of Manual</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>Initial Release</td>
<td>070503</td>
</tr>
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<td>1.1</td>
<td>Corrections to Configuration and Operation</td>
<td>071012</td>
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<td>1.2</td>
<td>Added information for PULS61, PULS62, and PULS68</td>
<td>081215</td>
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<td>1.3</td>
<td>Corrected running and standby mA</td>
<td>090409</td>
</tr>
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<td>1.4</td>
<td>Corrected specifications</td>
<td>090529</td>
</tr>
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<td>1.5</td>
<td>Changed company name, logo, and website</td>
<td>110301</td>
</tr>
</tbody>
</table>

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INTRODUCTION

About this Manual
This Technical Reference Manual has information for the setup, installation, and safe operation of the SDI-12 Radar Water Level Sensors. Please read this manual and make sure you understand all instructions before you begin using the equipment.

 Audience
The instructions in this manual are designed for qualified, trained personnel. Do not attempt to operate this equipment unless you have a thorough understanding of all the guidelines and procedures included in this reference manual.

Explanation of Symbols

- **Danger**
  Identifies an imminently hazardous situation which, if not avoided, will result in death or injury.

- **Warning**
  Identifies a potentially hazardous situation which, if not avoided, could result in death or injury.

- **Caution**
  Identifies a potentially hazardous situation which, if not avoided, may result in minor or moderate injury or in equipment damage.

- **Note**
  Identifies tips or useful information about the instrument.

- **AC current or voltage**
  A terminal to which or from which an alternating (sine wave) current or voltage may be applied or supplied.

- **DC current or voltage**
  A terminal to which or from which a direct current voltage may be applied or supplied.

- **Radiation**
  Introduces information concerning radioactive materials or radiation safety.

- **Potentially hazardous voltages**
  A terminal on which potentially hazardous voltage exists.

- **Protective ground terminal**
  Identifies location of terminal intended for connection to an external conductor.
Product Description

The VEGA SDI-12 Radar Water Level Sensors are pulse Radar (Radio Detection and Ranging) level sensors. These sensors are typically used in non-contact measurement of river, lake, tidal sea, and reservoir water levels. The sensors make multiple distance measurements. The results of those measurements are averaged and converted to read **Height** or **Stage** in units of feet or meters.

The SDI-12 Radar Water Level Sensors do not penetrate ice cover over rivers or lakes.

Features

There are three versions of the SDI-12 Radar Water Level Sensors. Each version has beneficial features such as the following:

<table>
<thead>
<tr>
<th>Feature</th>
<th>PS61</th>
<th>PS62</th>
<th>PS68</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measuring Range</td>
<td>Measuring Range - 20 meters</td>
<td>Measuring Range - 30 meters</td>
<td>Measuring Range - 70 meters</td>
</tr>
<tr>
<td>Non-contact level measurement</td>
<td>Non-contact level measurement eliminates the necessity for stilling wells or other infrastructure</td>
<td>Non-contact level measurement eliminates the necessity for stilling wells or other infrastructure</td>
<td>Non-contact level measurement eliminates the necessity for stilling wells or other infrastructure</td>
</tr>
<tr>
<td>Not fouled by debris, logs, or ice</td>
<td>Not fouled by debris, logs, or ice</td>
<td>Not fouled by debris, logs, or ice</td>
<td>Not fouled by debris, logs, or ice</td>
</tr>
<tr>
<td>±5.0mm accuracy</td>
<td>±3.0mm accuracy</td>
<td>±3.0mm accuracy</td>
<td>±15.0mm accuracy</td>
</tr>
<tr>
<td>Easy installation, use, and maintenance</td>
<td>Easy installation, use, and maintenance</td>
<td>Easy installation, use, and maintenance</td>
<td>Easy installation, use, and maintenance</td>
</tr>
<tr>
<td>Frequency range</td>
<td>Frequency range - K Band</td>
<td>Frequency range - K Band</td>
<td>Frequency range - K Band</td>
</tr>
<tr>
<td>No FCC license required</td>
<td>No FCC license required</td>
<td>No FCC license required</td>
<td>No FCC license required</td>
</tr>
<tr>
<td>Low current operation</td>
<td>Low current operation (6.0 mA is typical standby, 15 mA running continuously)</td>
<td>Low current operation (6.0 mA is typical standby, 15 mA running continuously)</td>
<td>Low current operation (6.0 mA is typical standby, 15 mA running continuously)</td>
</tr>
<tr>
<td>Continuous operation</td>
<td>Continuous operation</td>
<td>Continuous operation</td>
<td>Continuous operation</td>
</tr>
<tr>
<td>Extended SDI-12 commands</td>
<td>Extended SDI-12 commands implemented for customizing application.</td>
<td>Extended SDI-12 commands implemented for customizing application.</td>
<td>Extended SDI-12 commands implemented for customizing application.</td>
</tr>
</tbody>
</table>
Application
The SDI-12 Radar Water Level Sensors work with any data recorder/logger with an SDI-12 interface. The sensors are powered from the +12V wire of the 3-wire SDI-12 bus and are ideally suited for data logging applications meeting the following requirements:

- Battery powered operation that causes minimal current drain
- One data recorder that has multiple sensors on one cable
- Microprocessor-based sensors that can perform either complex calibrations or internal computations.
- These requirements are necessary to acquire the needed data at remote sites, since most of these sites operate for long and unattended periods of time.

SDI-12 System
SDI-12 is a serial/digital interface at 1200 baud and is a standard for interfacing data recorders with microprocessor-based sensors. The SDI-12 works as a master-slave system. The SDI-recorder (master) is connected to up to ten (10) SDI-12 sensors (slaves). The connecting line/bus consists of a three-wire cable. The three-wire cable has the following functions/connectors:

<table>
<thead>
<tr>
<th>Wire/Pin</th>
<th>Function/Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>+12V (power supply for sensor)</td>
</tr>
<tr>
<td>2</td>
<td>GND (power supply for sensor)</td>
</tr>
<tr>
<td>3</td>
<td>SDI-DATA (communication)</td>
</tr>
</tbody>
</table>

Figure 1.1 – SDI-12 Bus

1  Data Acquisition Device
2  Serial Data Line
3  12V (-) Ground
4  12V (+) Line
5  SDI-12 Sensor #2
6  SDI-12 Sensor #1
Data Acquisition
SDI-12 is the standard for interfacing data recorders with microprocessor-based sensors designed for EDA or environmental data acquisition. This data acquisition is completed with the use of a sensor and a data recorder. The recorder collects and saves the data.

The SDI-12 protocol is the standard communications protocol used to transfer the measurements taken by an intelligent sensor to a data recorder. That sensor usually takes the measurement, makes computations from that measurement, and then outputs the data in engineering units. For example, multiple measurements are taken by the sensor, averaged, and then converted to read **Height** or **Stage** in units of feet or meters.

Safety

General
Always refer to the safety instructions in this manual and the country specific installation standards. Follow the prevailing safety regulations and accident prevention rules set by your local governing authority.

The VEGA SDI-12 Radar Water Level Sensors require strict adherence to all safety regulations and guidelines. The emitting frequencies of all VEGA sensors are in the K Band range and are below the internationally permitted exposure or radiated energy limits.

Authorized Personnel
Only trained, authorized personnel should complete the procedures and operations described in this manual. For safety and warranty purposes, VEGA authorizes any internal work on the equipment by trained personnel only.

Inappropriate Use of Equipment
Inappropriate use of the equipment may damage the unit or create application-specific hazards.

FCC/IC Approval (United States and Canada only)
The SDI-12 Radar Water Level Sensors, with all antenna versions, are FCC approved and conform to Part 15 of the FCC regulations. Modifications to the sensors must have express agreement from VEGA. If the modifications are not agreed upon, the operating license to FCC expires. Regulations for operation include:

- These devices must not cause any interfering emissions.
- These devices must accept any interfering emissions received, including interference that may cause unwanted operating conditions.
INSTALLATION

Unpack the Equipment
When unpacking the SDI-12 equipment, complete the following:

- Unpack the unit in a clean, dry area.
- Inspect the equipment for any damage that occurred during shipping or storage.
- If the equipment is damaged, file a claim against the carrier and report the damage in detail. Any claim with VEGA for shortages, errors in shipment, or other problems must occur within 30 days of receipt of the shipment. Contact VEGA at 1-800-543-8668.

Components and Hardware
The SDI-12 Radar Water Level Sensor Radar Level gauges consist of an integrated microwave transmitter and sensor together with a horn antenna. The horn antenna serves to focus the transmitted signal and to receive the reflected echo. A built-in SDI-12 interface provides data processing and SDI-12 communications with the data logger.

Figure 2.1 – Components and Hardware for SDI-12
<table>
<thead>
<tr>
<th>Component</th>
<th>Hardware</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>PS61</td>
</tr>
<tr>
<td>(B)</td>
<td>PS62 or PS68</td>
</tr>
<tr>
<td>(C)</td>
<td>Optional Mounting Base</td>
</tr>
<tr>
<td>(D)</td>
<td>Optional Protective Shield</td>
</tr>
<tr>
<td>1</td>
<td>Mounting Loop</td>
</tr>
<tr>
<td>2</td>
<td>PULS Housing Side Cap</td>
</tr>
<tr>
<td>3</td>
<td>PULS Housing Cap</td>
</tr>
<tr>
<td>4</td>
<td>PULS Unit Secondary 1/2” NPT Cable Port, Primary Port on Opposite Side</td>
</tr>
<tr>
<td>5</td>
<td>PULS Instrument Horn</td>
</tr>
<tr>
<td>6</td>
<td>5/8” Hex Head Cap Screw &amp; Lock Washer</td>
</tr>
<tr>
<td>7</td>
<td>Swivel Mounting Flange</td>
</tr>
<tr>
<td>8</td>
<td>Upper Shield</td>
</tr>
<tr>
<td>9</td>
<td>Upper Shield Twist Lock Tab (3x)</td>
</tr>
<tr>
<td>10</td>
<td>Mounting Base</td>
</tr>
<tr>
<td>11</td>
<td>1/2” NPT, Mounting Base, Cable Entry Port</td>
</tr>
<tr>
<td>12</td>
<td>Lower Shield Locking Tab</td>
</tr>
<tr>
<td>13</td>
<td>Notch in Lower Shield Mounting Plate for Twist Lock Upper Shield</td>
</tr>
<tr>
<td>14</td>
<td>Lower Shield Mounting Stud, 5/8-11 (2x)</td>
</tr>
<tr>
<td>15</td>
<td>Lower Shield</td>
</tr>
</tbody>
</table>
Install the Radar Unit
The VEGA SDI-12 Radar Water Level Sensors are pulse Radar (Radio Detection and Ranging) level sensors. The SDI-12 is typically used in non-contact measurement of river, lake, tidal sea, and reservoir water levels. The sensors make multiple distance measurements. The results of those measurements are averaged and converted to read Height or Stage in units of feet or meters.

Figure 2.2 – SDI-12 Radar Water Level Sensor Applications
The SDI-12 is excellent where logs, debris, water traffic, or ice can damage stilling wells or other infrastructure. If you have installed the sensor over a bridge and the water below is shallow and has sandy bottoms, you can easily move the sensor if a storm shifts the river current.

General Installation Recommendations
Before installing the SDI-12 sensor, you must consider all the suggested guidelines for site and maintenance issues. Do not attempt to install the SDI-12 Radar Water Level Sensor unless you are qualified to perform the installation. The sensor is designed for safe operation in accordance with the current technical, safety and ANSI standards.

If you are uncertain of the safe installation and operation of this unit, read and understand all the instructions included in this manual before attempting any installation or operation.

Select a Location
Since the SDI-12 unit is commonly installed over water or from tall structures, make sure you use appropriate safety equipment such as a safety harness or a life preserver when you install or perform maintenance on the unit.

1. Handle the SDI-12 unit carefully, since it is a precision instrument.
2. Mount the sensor high enough to prevent submersion during flooding conditions.
3. Make certain the unit is mounted securely to prevent any movement.
4. Install the sensor above the smoothest part of the water surface.

![NOTE]

The smoothest part of the water surface is typically found between the bridge piers.

5. Align the antenna horn within 1° of vertical to prevent trigonometric measurement errors. (A level indicator is provided on the top cap of the unit for zero bubble).

6. Make sure you have no obstructions such as rough water, pipes, or logs between the sensor and the water. A path free of obstructions between the sensor and the water avoids false reflections.

![NOTE]

Try to locate the SDI-12 sensor so the beam path is clear. Usually the locations are 8° for a 4 inch horn antenna and 10° for a 3 inch horn antenna.

7. Try to locate the SDI-12 sensor so the beam path is clear. Center the sensor beam a minimum of 2.5m from any obstructions in the measurement range (up to 20m). The radiation beam spreads as it leaves the sensor as shown below.

<table>
<thead>
<tr>
<th>Beam Angle (PS62/PS68)</th>
<th>Distance in Meters</th>
<th>Diameter of Footprint in Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>8°</td>
<td>1</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>2.10</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>2.80</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>4.20</td>
</tr>
<tr>
<td></td>
<td>70</td>
<td>9.79</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Beam Angle (PS61)</th>
<th>Distance in Meters</th>
<th>Diameter of Footprint in Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>10°</td>
<td>1</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>2.62</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>3.50</td>
</tr>
</tbody>
</table>

8. Be aware that bridges contract and expand with temperature changes. Traffic loads or trucks can also cause changes to the bridge height.

9. Do not install the sensor where rocks, bridge piers, or other obstructions can affect the accurate measurement of the water level.

**Mount the Radar Unit**

**Vertical Alignment**

Make certain you align the antenna horn within 1° of vertical. If the antenna is not vertical, a trigonometric measurement error can occur with respect to the water. The maximum range is reduced because of the off-axis return signal.
**Azimuth Alignment**
The sensor’s radar beam is polarized so that it emits radar waves in an elliptical or football shape. You should orient the unit so the lobes are parallel to, and do not intersect the pier, when you install on a wall or close to a bridge pier. The Radar housing has a large hex nut on its mount stem. Two drill marks below the hex nut indicate which direction the lobes extend the least. Orient the sensor such that one of the marks is aligned *towards* the wall or pier.

![Figure 2.3 - Polarization Marking](image)

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PS61 Polarization marks are designated by the mounting loop screws.</td>
</tr>
<tr>
<td>2</td>
<td>PS62/PS68 Polarization mark is machine-tooled.</td>
</tr>
</tbody>
</table>

**Connect the Instrument Housing**
1. Unscrew the housing side compartment screw cap.
2. Loosen the cord grip on the cable entry.
3. Remove approximately 4 inches (10cm) of the cable mantle.
4. Strip approximately 0.4 inches (1cm) of the insulation from the end of the individual wires.
5. Insert the cable into the sensor through the cable entry.
6. Lift the opening levers of the terminals with a screwdriver.
7. Insert the wire ends into the open terminals.
   - Connect the Power Supply +12v DC to the terminals marked 1 (+).
   - Connect the Power Supply Ground to the terminals marked 2 (-).
   - Connect the Data Line to the terminals marked 3 (data).
8. Press the opening lever of the terminal down. You will hear the terminal spring closed.
9. Check that the wires are firmly connected in the terminal by lightly pulling on them.
10. Connect the screen to the internal ground terminal and the external ground terminal to potential equalization (ground).
11. Tighten the cord grip on the cable entry. The seal ring must completely encircle the cable.
12. Place the housing side compartment screw cap on and tighten to ensure a mechanical seal.

Figure 2.4 – Connecting the Instrument Housing
Adjust the Instrument Housing
After mounting, you can rotate the housing up to 350° to simplify access to the conduit entry and terminal compartment. Proceed as follows to rotate the housing to the desired position:

**Adjust the Housing**
1. Loosen the set screw on the housing.
2. Rotate the housing as desired.
3. Tighten the set screw.

<table>
<thead>
<tr>
<th>Connections</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A)</td>
<td>Side Chamber SDI-12 Wiring</td>
</tr>
<tr>
<td>(B)</td>
<td>Top Chamber Inner Housing Connections</td>
</tr>
<tr>
<td>(C)</td>
<td>Typical SDI-12 Network Configuration</td>
</tr>
<tr>
<td>(D)</td>
<td>DIS61 (Optional) (Reference V-2799S0)</td>
</tr>
<tr>
<td>1</td>
<td>Inner Housing Connections (Modular Plug Mounted in Dual Chamber Housing), Plugs into Back of SDI-12 Board</td>
</tr>
<tr>
<td>2</td>
<td>SDI-12 Data</td>
</tr>
<tr>
<td>3</td>
<td>Ground Connection</td>
</tr>
<tr>
<td>4</td>
<td>Data Acquisition Device</td>
</tr>
<tr>
<td>5</td>
<td>Serial Data Line</td>
</tr>
<tr>
<td>6</td>
<td>12V (-) Ground</td>
</tr>
<tr>
<td>7</td>
<td>12V (+) Line</td>
</tr>
<tr>
<td>8</td>
<td>SDI-12 Sensor #1</td>
</tr>
<tr>
<td>9</td>
<td>SDI-12 Sensor #2</td>
</tr>
<tr>
<td>10</td>
<td>Ground Connection</td>
</tr>
<tr>
<td>11</td>
<td>To Instrument</td>
</tr>
<tr>
<td>12</td>
<td>Remote Display</td>
</tr>
<tr>
<td>13</td>
<td>Ground Connection</td>
</tr>
<tr>
<td>14</td>
<td>Digital Output (To Optional Remote Display)</td>
</tr>
<tr>
<td>15</td>
<td>Plug for Laptop Connection</td>
</tr>
<tr>
<td>16</td>
<td>Remote Display</td>
</tr>
<tr>
<td>17</td>
<td>Red</td>
</tr>
<tr>
<td>18</td>
<td>Other</td>
</tr>
</tbody>
</table>
Make Connections to the SDI–12 Radar Water Level Sensor

A cable rated for water immersion (rain) and sunlight resistance is required, if the SDI-12 Radar Water Level Sensor is exposed to the sun and weather. Polyurethane or a similar sunlight and waterproof rated cable is recommended.

Do not use utility PVC or other wiring materials which can become brittle or crack when exposed to the sun.

When using conduit to connect to the SDI-12 Radar Water Level Sensor, follow these guidelines:

1. Remove and discard the liquid-tight cord retainer.
2. Ground the conduit, if metal conduit is used.
3. Seal the entry with silicone or similar sealant to prevent moisture from entering the SDI-12 Radar Water Level Sensor enclosure via the conduit piping.

The thermal mass of the casting may cause water vapor to internally condense and accumulate with changes in the weather. If conduit is used, make sure the conduit slopes down or has an adequate trap or seals.

Remove all power from the unit before making any connections.

All wiring must be done by qualified individuals in accordance with applicable codes such as the ANSI/NFPA 70 specifications or the Canadian Electrical Code Part 1.

Turn on Power

After connecting the SDI-12 unit to the power supply, the sensor performs a BIST (built-in self test) for approximately 80 seconds (factory default). During this self-check, an internal check of the electronics occurs.

During the initial power-up or resumption of supply voltage to the sensor, some SDI-12 commands, such as the I command, will not yield the expected responses.

A typical response to a \texttt{aD0!} command results in a response of 108003 where approximately 80 seconds is the required time to complete the BIST (Built in Self Test) of the instrument. After power-up is complete, normal SDI-12 communication starts.

Dispose of Equipment Materials

The SDI-12 sensors consist of materials which are recyclable at specialized recycling centers. VEGA uses recyclable materials and have also designed easily separable electronic modules.

Store the Equipment

Store the SDI-12 in an area that has a temperature between -40 °C and +80 °C (-40 °F and +176 °F) with a relative humidity of 20% to 80%.
CONFIGURATION

Factory Default
For most users, the SDI-12 Radar Water Level Sensors come from the factory pre-configured for most water level applications and are fully operable as shipped. The SDI-12 Radar Water Level Sensors are shipped with the following factory default settings.

<table>
<thead>
<tr>
<th>Default</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDI-12 Address</td>
<td>0</td>
</tr>
<tr>
<td>Units of Measure</td>
<td>feet</td>
</tr>
<tr>
<td>Water Stage</td>
<td>98 feet</td>
</tr>
<tr>
<td>Water Conditions</td>
<td>3 rough</td>
</tr>
<tr>
<td>Power Operation Mode</td>
<td>1 on</td>
</tr>
<tr>
<td>False Echo Learn</td>
<td></td>
</tr>
</tbody>
</table>

Command and Response Protocol
During normal communication, the SDI-12 recorder sends an address, together with a command, to the SDI-12 Radar Water Level Sensor. The sensor then replies with a "response". In the descriptions that follow, the SDI-12 commands and responses are enclosed in quotes. The SDI-12 address and the command/response terminators are defined as follows:

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>Is the sensor address. The following ASCII Characters are valid addresses: 0-9, AZ, a-z, *, ?. Sensors are initially programmed at the factory with the address of 0 for use in single sensor systems. Addresses 1 to 9 and A to Z or a to z are used for additional sensors connected to the same SDI-12 bus. Address * and ? are wild card addresses which select any sensor, regardless of its actual address.</td>
</tr>
<tr>
<td>Where:</td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>is the sensor address (0-9, A-Z, a-z, *, ?)</td>
</tr>
<tr>
<td>M</td>
<td>is an upper-case ASCII character</td>
</tr>
<tr>
<td>!</td>
<td>Is the last character of a command block</td>
</tr>
<tr>
<td>&lt;cr&gt;&lt;lf&gt;</td>
<td>Are carriage return (0D) hex and line feed (0A) hex characters. They are the last two characters of a response block</td>
</tr>
</tbody>
</table>

- All commands/responses are upper-case printable ASCII characters.
- Commands must be terminated with a ! character.
- Responses are terminated with <cr><lf> characters.
- The command string must be transmitted in a contiguous block with no gaps of more than 1.66 milliseconds between characters.
Startup Procedures
The basic startup procedures for the SDI-12 Radar Water Level Sensors require the following steps:

**Startup**
1. Mount, wire, and install the sensor (See Chapter 2, Installation).
2. Use the **Change Address** command to change to an available address slot.
3. Set the unit to feet using the **Set Unit** command.
4. Set the level of the water at the time with the **Set Water Stage** command.
5. Use the **Set Water Conditions** command to set the water conditions to what those conditions are at the time.
6. Set the power operation mode = ON with the **Power Operation Mode** command.
7. Start a **False Echo Learn** in DISTANCE to water from the bottom of the Radar flange in feet.

Refer to Appendix A for a full list of the SDI-12 commands and descriptions.

**Set the Address**
The factory default address is set to 0. Change this address by sending the unit the `aAb!` command where b is the new address you want. This address is verified by sending the unit the **Address Query** `??` command.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
</table>
| `aAb!`          | `b<cr><lf>`  
|                 | New address is set in response |

**Query the Address**
The **Address Query** Command gets the address in response to the **Change Address** command.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
</table>
| `??`            | `a<cr><lf>`  
|                 | Gets the address from the SDI-12 Radar sensor. |
Set Units
The **Set Unit** command sets the SDI-12 sensor measurement distance between the unit and the surface water level in meters or feet.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aXSU+1!</td>
<td>a0011&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

**Subsequent Command**

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aD0!</td>
<td>a+1&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

0 = m is the current unit in meters
1 = ft is the current unit in feet

Set Water Stage
The **Set Water Stage** command sets the water stage in the SDI-12 sensor. Use this value to calculate the stage for measurements. When you set the water stage, the sensor measures the actual distance to the water level in meters or feet. You can find out if the sensor is set in meters or feet with the **Get Unit** command (See Appendix A).

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aXS$+7.010!</td>
<td>a0011&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

**Subsequent Command**

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aD0!</td>
<td>a+7.010&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

Where 7.010 is the current stage in m or ft (depending on setting of unit)

Set Water Conditions
Use the **Set Water Conditions** command to adapt the SDI-12 sensor to different water conditions. There are three different settings:

- **Smooth** (typical peak to trough of wave ≤ 4")
- **Medium** (typical peak to trough of wave ≤ 8")
- **Rough** (typical peak to trough of wave > 8")

The factory default water conditions are set to 3 which is rough. The water condition settings should closely mimic the actual water conditions during normal river flow..

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aXSWC+1!</td>
<td>a0011&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

**Subsequent Command**

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aD0!</td>
<td>a+1&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

Where
+1 is the current water condition
1 = smooth
2 = medium
3 = rough
0 = undefined (custom settings)
**Set Power Operation Mode**

The factory default power operation mode is ON. In this mode of operation, the instrument is continuously making measurements and draws approximately 13.5mA. The alternate mode of operation (AUTO) puts the instrument in quiescent mode between measurement request queries.

The **Set Power Operation Mode** command changes the sensor’s power mode:

- **Auto**: The SDI-12 Radar is powered by an incoming request from the SDI-12 bus and sends back a response including the information on power up time.
- **ON**: The sensor is always on until a new `aXSPOM!` command is received.
- **OFF**: The SDI-12 is always off until a new `aXSPOM!` command is received.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aXSPOM+2!</code></td>
<td><code>a0011&lt;cr&gt;&lt;lf&gt;</code></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aD0!</code></td>
<td><code>a+2&lt;cr&gt;&lt;lf&gt;</code></td>
</tr>
<tr>
<td></td>
<td>Where +2 is the current power operation mode</td>
</tr>
<tr>
<td></td>
<td>0 (OFF)</td>
</tr>
<tr>
<td></td>
<td>1 (ON)</td>
</tr>
<tr>
<td></td>
<td>2 (AUTO)</td>
</tr>
</tbody>
</table>

**Start False Echo Learn**

The **Start False Echo Learn** command is an essential function during the startup of the SDI-12 sensor. The command allows the unit to “learn out” any or all false noise in the area by getting a distance measurement between the instrument and the surface water level. The **False Echo Learn** is the actual distance to “learn” noise, as measured in meters or feet, depending on the Unit setting.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aXSFEL+2.500!</code></td>
<td><code>a2001&lt;cr&gt;&lt;lf&gt;</code></td>
</tr>
<tr>
<td></td>
<td><code>a&lt;cr&gt;&lt;lf&gt;!</code></td>
</tr>
<tr>
<td></td>
<td>Note: You must wait the specified time (200 seconds) before sending the <code>aD0!</code> command</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aD0!</code></td>
<td><code>a+2.500!</code></td>
</tr>
<tr>
<td></td>
<td>Where +2.500 is the distance to the real water level</td>
</tr>
</tbody>
</table>

**Request Measurement Values**

The **Start Measurement** command requests measurement values from the VEGA sensor. The **Measurement** command is always followed by a subsequent data command. The SDI-12 Radar unit gives three measurements to the SDI-12 recorder.

**Stage**

The present water level as measured in meters or feet. This measurement is dependent on the **Stage** adjustment and the **Unit** set in the SDI-12 sensor.
Distance
The present distance to the water surface in meters or feet. This measurement is independent from the Stage adjustment.

Diagnostic Values
These values are error codes as defined for the VEGA sensor. For example, Code 0 = OK, Code 13 = error E013. The measuring unit for Stage and Distance is per the Set Unit command.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aM!</td>
<td>a0023&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aD0!</td>
<td>a+AAA.AAA+BBB.BBB+CC&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

Where:
AAA.AAA is the stage in meters or feet
BBB.BBB is the distance in meters or feet
CC is the error code

Test Procedures
The test procedures for the SDI-12 Radar Water Level Sensors require the following steps:

Testing
1. Double check all wiring connections.
2. Connect the SDI-12 Radar Water Level Sensor to your data recorder and apply +12V power.
3. Compare the Output Stage versus the Actual Stage using the Start Measurement command aM! followed by the aD0! command.
4. Send the Acknowledge Active command a!.
5. Send the Identification command a! !.
6. Send the Start Verification command aV! followed by the aD0! command.
7. Use the Get Unit command aXGU!.
8. Use the Get Water Condition command aXGWC!.

**Check Unit Response**
The **Acknowledge Active** command is used to check the presence of the SDI-12 sensor on the bus.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>a!</code></td>
<td><code>a&lt;cr&gt;&lt;lf!&gt;</code></td>
</tr>
<tr>
<td></td>
<td>Only the address is sent back in response.</td>
</tr>
</tbody>
</table>

**Check for Valid Data**
The **Send Identification** command gets the following identification information in response to sending `a!`.

- Compatibility level: Version of SDI-12 protocol version. For example, 1.3
- Company Name: VEGA
- Sensor Model Number: PULS62
- Three Digit Firmware Version Number.
- Eight Digit Serial Number of Sensor.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>a!!</code></td>
<td><code>a13VEGAAbbbbPULS6233212345678&lt;cr&gt;&lt;lf&gt;</code></td>
</tr>
<tr>
<td></td>
<td>SDI-12 compatibility number = 13</td>
</tr>
<tr>
<td></td>
<td>Company Name = VEGA</td>
</tr>
<tr>
<td></td>
<td>Sensor Model Number = PULS62</td>
</tr>
<tr>
<td></td>
<td>Sensor Version Number = 3.32</td>
</tr>
<tr>
<td></td>
<td>Serial Number = 12345678</td>
</tr>
</tbody>
</table>

**Cyclic Redundancy Check (CRC)**
A cyclic redundancy check (CRC) is used to produce and send a small, fixed-size checksum of a larger block of data to the SDI-12 data recorder. This checksum detects errors after transmission or storage. The CRC is computed and added before any transmission or storage. The CRC is also authenticated by the recipient, after the transmission, to confirm that no alterations occurred. CRCs are very good at identifying errors caused by noise in transmission channels.
Check CRC for Valid Data
The **Start Verification** command requests verification of three values from the VEGA sensor. Those three values are:

- CRC check (error check)
- SDI-12 Radar firmware version number
- HART Sensor firmware version

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aV!</td>
<td>a0013&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aD0!</td>
<td>a0+01610000+3320000&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

  CRC check (0 = OK, 1 = Failed)
  Adapter version. For example, 1.61.00.00
  Sensor version. For example, 3.32.00.00

Get Units
The **Get Unit** command reads the current SDI-12 sensor measurement distance between the unit and the surface water level in meters or feet.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aXGU!</td>
<td>a0011&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aD0!</td>
<td>a+m&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

  0 = is the current unit in meters
  1 = is the current unit in feet

Get Water Conditions
The **Get Water Conditions** command checks the current setting of the water conditions.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aXGWC+1!</td>
<td>a0011&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aD0!</td>
<td>a+1&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

  Where
  +1 is the current water condition
  1 = smooth
  2 = medium
  3 = rough
  0 = undefined (custom settings)
Get Power Operation Mode
The **Get Power Operation Mode** command reads the power operation mode of the SDI-12 sensor.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aXGPOM!</code></td>
<td><code>a0011&lt;cr&gt;&lt;lf&gt;</code></td>
</tr>
</tbody>
</table>

**Subsequent Command**

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aD0!</code></td>
<td><code>a+1&lt;cr&gt;&lt;lf&gt;</code></td>
</tr>
</tbody>
</table>

Where
- `+1` is the current power operation mode
- 2 (AUTO)
- 1 (ON)
- 0 (OFF)

Set False Echo Learn
Use **False Echo Learn** command during the test procedures of the SDI-12 sensor if you encounter a problem. The command allows the unit to “learn out” any or all false noise in the area by getting a distance measurement between the instrument and the surface water level. The **False Echo Learn** is the actual distance to “learn” noise, as measured in meters or feet, depending on the **Unit** setting.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aXSFE+2.500!</code></td>
<td><code>a2001&lt;cr&gt;&lt;lf&gt;</code></td>
</tr>
</tbody>
</table>

**Subsequent Command**

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aD0!</code></td>
<td><code>a+2.50&lt;cr&gt;&lt;lf&gt;</code></td>
</tr>
</tbody>
</table>

Note: You must wait the specified time (200 seconds) before sending the `aD0!` command.
**OPERATION**

**Principle of Operation**

The SDI-12 Radar Water Level Sensors are Radar sensors in K Band (emitting frequency approximately 26 GHz) for continuous level measurement. Use the SDI-12 for water level measurements in rivers, streams, and other waterways.

The antenna of the SDI-12 sensors emit short Radar pulses with a duration of approximately 0.1ns. These pulses are redirected by the water surface and received by the antenna as echoes. The running time of the Radar pulses from emission to reception is proportional to the distance to the water surface and to the sensor. The determined level is converted into an appropriate output signal and reported as a measured value.

The power supply required to power the SDI-12 is 12 VDC with a minimum current supply of 15 mA (typical 13.5 mA in power operating mode).

**Command and Response Protocol**

During normal communication, the SDI-12 recorder sends an address, together with a command, to the SDI-12 Radar Water Level Sensor. The sensor then replies with a "response." The SDI-12 address and the command/response terminators are defined as follows:

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>a</strong></td>
<td>Is the sensor address. The following ASCII Characters are valid addresses: 0-9, AZ, a-z, *, ?. Sensors will be initially programmed at the factory with the address of 0 for use in single sensor systems. Addresses 1 to 9 and A to Z or a to z can be used for additional sensors connected to the same SDI-12 bus. Address * and ? are wild card addresses which select any sensor, regardless of its actual address.</td>
</tr>
<tr>
<td><strong>M</strong></td>
<td>is an upper-case ASCII character</td>
</tr>
<tr>
<td><strong>!</strong></td>
<td>Is the last character of a command block</td>
</tr>
<tr>
<td><code>&lt;cr&gt;&lt;lf&gt;</code></td>
<td>Are carriage return (0D) hex and line feed (0A) hex characters. They are the last two characters of a response block</td>
</tr>
</tbody>
</table>

- All commands/responses are upper-case printable ASCII characters.
- Commands must be terminated with a ! character.
- Responses are terminated with `<cr><lf>` characters.
- The command string must be transmitted in a contiguous block with no gaps of more than 1.66 milliseconds between characters.
Request Measurement Values
The **Start Measurement** command requests measurement values from the VEGA sensor. The **Measurement** command is always followed by a subsequent data command. The SDI-12 Radar unit gives three measurements to the SDI-12 recorder.

**Stage**
The present water level as measured in meters or feet. This measurement is dependent on the Stage adjustment and the Unit set in the SDI-12 sensor.

**Distance**
The present distance to the water surface in meters or feet. This measurement is independent from the Stage adjustment.

**Diagnostic Values**
These values are error codes as defined for the VEGA sensor. For example, Code 0 = OK, Code 13 = error E013. The measuring unit for Stage and Distance is per the Set Unit command.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aM!</td>
<td>a0023&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aDO!</td>
<td>a+AAA.AAA+BBB.BBB+CC&lt;cr&gt;&lt;lf&gt;</td>
</tr>
</tbody>
</table>

Where:
- AAA.AAA is the stage in meters or feet
- BBB.BBB is the distance in meters or feet
- CC is the error code

- The **Measurement** command tells the SDI-12 Radar Water Level Sensor to take a measurement. The SDI-12 does not return the measurement data to the SDI-12 recorder in the response to this command.

- The SDI-12 unit returns the time and the count of the number of measurements that are sent after the time has elapsed. If the sensor completes the measurement before the specified time in the response, the unit can issue a service request to the SDI-12 recorder.

- The SDI-12 recorder should issue the data command after the time elapses. The SDI-12 sensor can send all the measured values at one time or one at a time. Depending on the number of measurement values, the SDI-12 recorder received from the sensor, the recorder sends the next data command.

- If the SDI-12 recorder receives a data command and the measurement data is not ready, the sensor returns the time and count number of measurements again.
**Concurrent Measurement**

The **Concurrent Measurement** command is new for the Version 1.2 SDI-12 Specification. A concurrent measurement is one which occurs while other SDI-12 sensors on the bus are also taking measurements. This command is similar to the \texttt{aM!} command, however, the \texttt{nn} field has an extra digit and the sensor does not issue a service request when it has completed the measurement. Communicating with other sensors will NOT abort a concurrent measurement. Data values generated in response to this command are stored in the sensor's buffer for subsequent collection using \texttt{D} commands. The data is retained in the sensor until another \texttt{M}, \texttt{C}, or \texttt{V} command is executed.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{aC!}</td>
<td>\texttt{ttt nn&lt;cr&gt;&lt;lf&gt;}</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{a}</td>
<td>is the sensor address (0-9, A-Z, a-z, *, ?).</td>
</tr>
<tr>
<td>\texttt{C}</td>
<td>is an upper-case ASCII character.</td>
</tr>
<tr>
<td>\texttt{ttt}</td>
<td>is a three digit integer (000-999) specifying the maximum time, in seconds, the sensor will take to complete the command and have measurement data available in its buffer.</td>
</tr>
<tr>
<td>\texttt{nn}</td>
<td>is a two digit integer (00-99) specifying the number of values that will be placed in the data buffer. If \texttt{n} is zero (0), no data will be available using subsequent \texttt{D} commands.</td>
</tr>
</tbody>
</table>

The data recorder may wake the sensor with a break and collect the data anytime after the specified processing time has elapsed.

**Continuous Measurements**

This is a new command for the Version 1.2 SDI-12 Specification. Sensors that are able to continuously monitor the phenomena to be measured, such as a cable position, do not require a start measurement command. They can be read directly with the \texttt{R} commands (\texttt{R0! ... R9!}). The \texttt{R} commands work exactly like the \texttt{D} (\texttt{D0! ... D9!}) commands. The only difference is that the \texttt{R} commands do not require a preceding \texttt{M} command.

The SDI-12 Radar Water Level Sensors **do not** support the \texttt{aRO!} continuous measurement commands because the measurement and math operations require several seconds to complete.

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{aRO!}</td>
<td>This command is used to request measurement values from the VEGA sensor. The command is used when you want to read the data continuously. No measurement command is sent by the SDI-12 recorder. Poll the VEGA sensor continuously to get the latest measurements. If no SDI-12 command is received continuously for 5 seconds, the SDI-12 Radar sensor keeps polling measurement values. If any SDI-12 command is received, the SDI-12 Radar sensor stops background measurement polling and executes the command received.</td>
</tr>
</tbody>
</table>
## Start Measurement and Request CRC

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aMC!</td>
<td>The response to this command is similar to the <strong>Start Measurement</strong> command response of <code>a0023&lt;cr&gt;&lt;lf&gt;</code></td>
</tr>
</tbody>
</table>

## Additional Measurements

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
</table>
| aM1!            | This command is used to request additional measurement values from the VEGA sensor. The response to the **Additional Measurements** command is similar to the **Start Measurement** command response of `a1103<cr><lf>`.

## Additional Measurements and Request CRC

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
</table>
| aMC1!           | This command is used to request additional measurement values from the VEGA sensor. The response to the **Additional Measurements** and CRC command is similar to the **Start Measurement** command response of `a1103<cr><lf>`.

## Start Concurrent Measurements

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
</table>
| aC!             | This command is used when the SDI-12 recorder wants to measure data of different slaves simultaneously. No response is issued by the SDI-12 Radar sensor even if the recorder is finished with its measurements. The response to the **Start Concurrent Measurements** command is similar to the **Start Measurement** command response of `a1103<cr><lf>`.

## Additional Concurrent Measurements

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
</table>
| aC1!            | This command is used to request additional measurement values from the VEGA sensor. This command is used when the SDI-12 recorder wants to measure data of different slaves simultaneously. No response is issued by the SDI-12 Radar sensor even if the recorder is finished with its measurements. The response to the **Start Concurrent Measurements** command is similar to the **Start Measurement** command response of `a1103<cr><lf>`.


## Start Concurrent Measurements and Request CRC

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aCC!</code></td>
<td>This command is used to request additional measurement values from the VEGA sensor with CRC. This command is used when the SDI-12 recorder wants to measure data of different slaves simultaneously. No response is issued by the SDI-12 Radar sensor even if the recorder is finished with its measurements. The response to the <strong>Start Concurrent Measurements</strong> command is similar to the <strong>Start Measurement</strong> command response of <code>a0023&lt;cr&gt;&lt;lf&gt;</code>.</td>
</tr>
</tbody>
</table>

## Continuous Measurements and Request CRC

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aR1!</code></td>
<td>This command is used to request measurement values from the VEGA sensor with CRC. This command is used when the user wants to read the data continuously. No measurement command is sent by the SDI-12 recorder. Poll the VEGA sensor continuously to get the latest measurements. If no SDI-12 command is received continuously for 5 seconds, the SDI-12 Radar sensor keeps polling measurement values. If any SDI-12 command is received, the SDI-12 Radar sensor stops background measurement polling and executes the command received.</td>
</tr>
</tbody>
</table>

## Additional Concurrent Measurements and Request CRC

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>aCC1!</code></td>
<td>This command is used to request additional measurement values from the VEGA sensor with CRC. This command is used when the SDI-12 recorder wants to measure data of different slaves simultaneously. No response is issued by the SDI-12 Radar sensor even if the recorder is finished with its measurements. The response to the <strong>Start Concurrent Measurements</strong> command is similar to the <strong>Start Measurement</strong> command response of <code>a0023&lt;cr&gt;&lt;lf&gt;</code>.</td>
</tr>
</tbody>
</table>
Reset Sensor

The **Reset Sensor** command resets all the parameters in the SDI-12 sensor. SDI-12 settings such as **Stage**, **Unit**, and **Power Operation Mode** are not reset.

**NOTE**

<table>
<thead>
<tr>
<th>Initial Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aXRS!</td>
<td>a0401&lt;cr&gt;&lt;lf!&gt;</td>
</tr>
<tr>
<td></td>
<td>Note: You must wait the specified time before sending the aD0! command</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subsequent Command</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>aD0!</td>
<td>a+1&lt;cr&gt;&lt;lf!&gt;</td>
</tr>
</tbody>
</table>

**Where:**

+1 = reset is finished and successful
+0 = reset failed
DIAGNOSTICS AND REPAIR

General Diagnostics and Repair

The VEGA SDI-12 RADAR Water Level Sensors are extremely reliable, but problems can occur during operation. Most of these problems are caused by the following:

- Sensor
- Environmental Conditions
- Power Supply
- Signal Processing

When you encounter a problem with the SDI-12, check the error messages from the aM!, followed by the aD0! command to help evaluate the issue.

Use the software PACTware™ and a suitable DTM to gather more comprehensive diagnostics and determine the exact cause of many issues.

During the initial power-up or resumption of supply voltage to the sensor, some SDI-12 commands, such as the I command, will not yield the expected responses.

A typical response to a aD0! command results in a response of 108003 where approximately 80 seconds is the required time to complete the BIST (Built in Self Test) of the instrument. After power-up is complete, normal SDI-12 communication starts.

*NOTE*

No Measured Value Available – Error E013

If you are unable to find a measured value, check the following:

- Sensor in boot phase
- Update the Start False Echo Learn (aXSFEL).

No Measured Value Available – Error E041, E042, E043

If you have a hardware error or have defective electronics, complete the following:

- Cycle the power to the unit. If the sensor recovers, no further steps are required.
- Exchange the equipment
- Return the equipment for repair

Exchange SDI-12 Electronics

If you do not have an electronics module onsite, order one from VEGA.

Change the SDI-12 Electronics

If the electronics module is defective, replace it using the following steps:

1. Unscrew the housing cap. Cap is not shown.
2. Remove all wires that are attached or plugged into the electronics and note their location for re-assembly.
3. Loosen the two (2) screws “A” securing the electronics to the housing. These screws are captive screws and will remain nested with the electronics.

4. Gently remove the electronics “B” from the housing.

Some friction is normal when removing the electronics because a seal is between the electronics and the lower portion of the housing.

5. Replace the electronics with a new module.

Make sure the two (2) screws holding the electronics module in are tight, but do not overtighten. Overtightening these screws can strip the threads.

6. Tighten the two (2) screws “A” to secure the electronics to the housing.

7. Re-assemble all wires that were originally attached or plugged into the electronics.

8. Tighten the housing cap.

![Figure 5.1 - Changing the Electronic Module](image-url)
### Maintenance

**Normal Operation**

The VEGA SDI-12 RADAR Water Level Sensors are maintenance free under normal operation.
### APPENDIX A

#### SDI-12 Commands Reference Sheet

For a more detailed description of the SDI-12 commands and their structure, please refer to Chapters 3 and 4.

<table>
<thead>
<tr>
<th>Description</th>
<th>Basic Commands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address Query</td>
<td>aI!</td>
</tr>
<tr>
<td>Send Identification</td>
<td>aI!</td>
</tr>
<tr>
<td>Acknowledge Active</td>
<td>a!</td>
</tr>
<tr>
<td>Change Address</td>
<td>aAb!</td>
</tr>
<tr>
<td>Start Verification</td>
<td>aV!</td>
</tr>
<tr>
<td>Start Measurement</td>
<td>aM!</td>
</tr>
<tr>
<td>Start Measurement and Request CRC</td>
<td>aMC!</td>
</tr>
<tr>
<td>Send Data</td>
<td>aD0!...aD9!</td>
</tr>
<tr>
<td>Additional Measurements</td>
<td>aM1!...aM9!</td>
</tr>
<tr>
<td>Additional Measurement and Request CRC</td>
<td>aMC1!...aMC9!</td>
</tr>
<tr>
<td>Start Concurrent Measurement</td>
<td>aC!</td>
</tr>
<tr>
<td>Start Concurrent Measurement and Request CRC</td>
<td>aCC!</td>
</tr>
<tr>
<td>Additional Concurrent Measurements</td>
<td>aC1!...aC9!</td>
</tr>
<tr>
<td>Additional Concurrent Measurements and Request CRC</td>
<td>aCC1!...aCC9!</td>
</tr>
<tr>
<td>Continuous Measurements</td>
<td>aR0!...aR9!</td>
</tr>
<tr>
<td>Continuous Measurements and Request CRC</td>
<td>aRC0!...aRC9!</td>
</tr>
<tr>
<td>Description</td>
<td>Extended Commands</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------</td>
</tr>
</tbody>
</table>
| Start False Echo Learn | `aXFEL+n!`  
   *n*=distance necessary to clear the obstruction |
| Get Power Operation Mode (ON, OFF, AUTO) | `aXGPO!`  
   *2*=auto; *1*=on; *0*=off |
| Set Power n Operation Mode (ON, OFF, AUTO) | `aXSPOM+n!`  
   *n*=the new Power Operation Mode |
| Get Water Conditions | `aXGWC!`  
   *0*=undefined; *1*=smooth; *2*=medium; *3*=rough |
| Set Water Conditions  
   Where n is the new Water Condition | `aXSWC+n!`  
   *0*=undefined; *1*=smooth; *2*=medium; *3*=rough |
| Set Water Stage  
   Where n is the new Water Stage | `aXSS+n!` |
| Get Unit | `aXGU!`  
   *0*=meters; *1*=feet |
| Set Unit  
   Where n is the new unit of measurement | `aXSU+n!`  
   *0*=meters; *1*=feet |
| Reset Sensor  
   Resets the sensor to its factory settings | `aXRS!`  
   *0*=reset unsuccessful; *1*=reset successful |
**APPENDIX B**

**Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measurement</strong></td>
<td></td>
</tr>
<tr>
<td>Standard Range</td>
<td>20m, 30m, 70m</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±5mm, ±3 mm, ±15mm</td>
</tr>
<tr>
<td><strong>Radar Unit</strong></td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>~26 GHz</td>
</tr>
<tr>
<td>Electromagnetic Compatibility</td>
<td>Emission to EN 61326 Electrical Equipment Class B</td>
</tr>
<tr>
<td>Pulse Energy</td>
<td>1mW max</td>
</tr>
<tr>
<td>Beam angle</td>
<td>10° (3-in dia horn) - PS61 8° (4-in dia horn) - PS62/PS68</td>
</tr>
<tr>
<td>Measuring Distance Beam Diameter (3-in Horn)</td>
<td>10 ft (3 m) 1.75 ft (0.5 2m) 20 ft (6 m) 3.50 ft (1.05m) 30 ft (9 m) 5.25 ft (1.57 m) 40 ft (12 m) 7.00 ft (2.1 m) 49 ft (15 m) 8.57 ft (2.62 m) 65 ft (20 m) 11.37 ft (3.50 m)</td>
</tr>
<tr>
<td><strong>SDI-12 Output</strong></td>
<td></td>
</tr>
<tr>
<td>Output Signal</td>
<td>12V/SDI-12 (digital only)</td>
</tr>
<tr>
<td>Resolution</td>
<td>1mm / 1/1000ft.</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>1200 bps</td>
</tr>
<tr>
<td>Data Signal</td>
<td>0 V for logical “1” / 5 V for logical “0”</td>
</tr>
<tr>
<td>Protocol</td>
<td>SDI-12, 7-bit even parity, 1 stop bit</td>
</tr>
<tr>
<td>Output Voltage Levels</td>
<td>Minimum high level: 3.5 volts Maximum low level: 0.8 volts</td>
</tr>
<tr>
<td><strong>Response Time</strong></td>
<td></td>
</tr>
<tr>
<td>SDI-12 measurement sequence</td>
<td>1 sec (typ) 5 sec (max)</td>
</tr>
<tr>
<td><strong>Power Requirements</strong></td>
<td></td>
</tr>
<tr>
<td>Voltage Input</td>
<td>Typ. 12V DC (9.6 to 16 V DC)</td>
</tr>
<tr>
<td>Surge Protection</td>
<td>Built in, 1.5 KVA</td>
</tr>
<tr>
<td>Supply Current</td>
<td>Typ. 15mA running/6.0mA standby</td>
</tr>
<tr>
<td><strong>Electrical Protective Measures</strong></td>
<td></td>
</tr>
<tr>
<td>Overvoltage category</td>
<td>III</td>
</tr>
<tr>
<td>Protection Class</td>
<td>II</td>
</tr>
</tbody>
</table>
The sensor electronic must have the Multidrop-Mode set at address “1”. With the address set at “1”, a current of 22mA never appears.

The SDI-12 RADAR Water Level Sensors are warranted against defects in materials and workmanship for one year from date of shipment.

Specifications are subject to change without prior notice due to product testing and improvement.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental</td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-40° C to +80° C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>-40° C to +80° C / -40° F to +176° F</td>
</tr>
<tr>
<td>Temperature Sensitivity</td>
<td>average Tx: 2 mm/10 K, max 5 mm over the entire temperature range -40° C to +80° C</td>
</tr>
<tr>
<td>Vibration Resistance</td>
<td>Mechanical vibrations with 4g and 5/100 Hz</td>
</tr>
<tr>
<td>Mechanical</td>
<td></td>
</tr>
<tr>
<td>Housing</td>
<td>Aluminum</td>
</tr>
<tr>
<td>Horn size</td>
<td>3-inch (L = 113 mm, d = 80 mm) 4-inch (L = 430 mm, d = 95 mm)</td>
</tr>
<tr>
<td>Horn Material</td>
<td>316L stainless steel</td>
</tr>
<tr>
<td>Electromechanical*</td>
<td></td>
</tr>
<tr>
<td>Spring loaded terminals</td>
<td>For wire cross section up to 2,5mm²</td>
</tr>
<tr>
<td>Connections</td>
<td></td>
</tr>
<tr>
<td>+12V &amp; SDI-12</td>
<td>Internal 3-position connector. 6-ft polyurethane pigtail is provided.</td>
</tr>
<tr>
<td>SDI-12 Interface</td>
<td></td>
</tr>
<tr>
<td>- Pin 1: +12V</td>
<td>SDI-12 Power supply from SDI-12 bus</td>
</tr>
<tr>
<td>- Pin 2: GND</td>
<td>SDI-12 Power supply from SDI-12 bus</td>
</tr>
<tr>
<td>- Pin 3: SDI-DATA</td>
<td>SDI-12 Data communication</td>
</tr>
<tr>
<td>Power Consumption of SDI-12 Interface (with HART interface connected and sensor in Multidrop-mode)</td>
<td></td>
</tr>
<tr>
<td>Input voltage range</td>
<td>9.6V ... 16V</td>
</tr>
<tr>
<td>Input current range</td>
<td>expected: 17mA ... 40mA</td>
</tr>
</tbody>
</table>

* The sensor electronic must have the Multidrop-Mode set at address “1”. With the address set at “1”, a current of 22mA never appears.

The SDI-12 RADAR Water Level Sensors are warranted against defects in materials and workmanship for one year from date of shipment.

Specifications are subject to change without prior notice due to product testing and improvement.
APPENDIX C

FCC/IC Equipment Authorization

Conformity (USA/Canada)
The SDI-12 Radar Water Level Sensors are FCC approved. Any modifications not approved by VEGA will cause the expiration of the operating license issued by the FCC/IC.
The SDI-12 is in conformity with Part 15 of the FCC directives and fulfills the RSS-210 regulations.
NOTES
APPENDIX D

Customer Service

Where to Find Help
If you need help finding information, check the Index and Table of Contents within this manual. Also, refer to the information on Calibration and Operation with the SDI-12.

VEGA Customer Service
VEGA Customer Service has Field Service Engineers located across the U.S. In many cases, a Field Service Engineer will be at your plant for the start up of your gauge. Also, Field Service Engineers regularly assist customers over the phone. If you have a question or need help, call Customer Service during office hours. If your problem is an emergency (for example, line shut down because of VEGA equipment), you can reach us 24-hours a day.

<table>
<thead>
<tr>
<th>Contact Information</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Tel (Monday – Friday 8:00 A.M. – 5:00 P.M. EST)</td>
<td>+1 513-272-0131</td>
</tr>
<tr>
<td>Tel (emergencies: follow the voice mail instructions)</td>
<td>+1 513-272-0131</td>
</tr>
<tr>
<td>Fax</td>
<td>+1 513-272-0133</td>
</tr>
</tbody>
</table>

VEGA can provide field service for customers outside the U.S. and Canada. In addition, customers outside the U.S. and Canada may contact their local VEGA representative for parts and service.

Return Equipment for Repair to VEGA
Have this information ready:
- Product model that is being returned for repair
- Description of the problem
- VEGA Customer Order (C.O.) Number
- Purchase order number for the repair service
- Shipping address
- Billing address
- Date needed
- Method of shipment
- Tax information

To Return Equipment for Repair
1. Contact your local VEGA representative and ask for repair service. See the Contact Information below.
2. VEGA assigns the job a material return authorization (MRA) number.

   You must first contact VEGA and receive a material return authorization number (MRA) before returning any equipment. VEGA reserves the right to refuse any shipment not marked with the MRA number.

3. Indicate the MRA on the repair service purchase order.
4. Clearly mark the shipping package with the MRA number.
5. Send the confirming purchase order and the equipment to:

   VEGA Americas, Inc
   Attention: Repair Department
   4170 Rosslyn Drive
   Cincinnati, Ohio 45209-1599 USA
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All statements concerning scope of delivery, application, practical use, and operating conditions of the sensors and processing systems correspond to the information available at the time of printing.

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