Laser Technology, Inc.

TruSense® S300 Series

User's Manual

LTI TruSense® S300 Series User's Manual
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1 Introduction

Purpose

This document defines and provides the means to control and integrate the Laser Technology TruSense S300-series liquid laser sensor for the following configurations:

	I/O				
	Visible Alignment Laser	**RS232**	**SDI 12**	**4-20**	**Trigger**
S300		●	●		●
S310	●	●	●		●
S330	●	●		●	

Table 1: Outputs for Each Model

S3xx is used as a generic term for all S300 models in this manual.

Basic Package

- ☐ S300 Series Sensor or S300 Series OEM Sensor
- ☐ Communication Cable with Flying Leads
- ☐ LTI Limited Warranty

Accessory Items

- ☐ Power/Comm Cable
- ☐ Universal Mounting Plate
- ☐ Diffuser Lenses
- ☐ Sun Shade

For more information on S300 series accessories, please visit: http://www.lasertech.com/Laser-Sensors.aspx

Safety Precautions

- Avoid staring directly at the laser beam for prolonged periods. The TruSense S300 is designed to meet FDA eye safety requirements and is classified as eye safe to FDA (CFR21) Class I 7 mm limits, which means that virtually no hazard is associated with directly viewing the laser output under normal conditions. As with any laser device, however, reasonable precautions should be taken in its operation.
- It is recommended that you avoid staring into the transmit aperture while firing the laser. The use of optical instruments with this product may increase eye hazard.
- Do not use the laser within 15 meters (50 feet) of a prism. The reflective energy from a prism within this range can oversaturate the laser receiver, resulting in permanent damage to the sensor.
- Never point the instrument directly at the sun. Exposing the lens system to direct sunlight, even for a brief period, may permanently damage the laser receiver and/or transmitter.
- Effective for the S310 and S330 only: The Class 2 Alignment Laser Exit Aperture is located on the upper portion of the Front Plate between the Transmit and Receive Lenses of the Class 1 Measurement Laser:

ALIGNMENT LASER = CLASS 2
MEASUREMENT LASER = CLASS 1

Mounting the TruSense S300

IMPORTANT!
When mounting the S300, always use a washer between the housing feet and the screw head. Do not exceed 5 inch-pounds of torque when securing.

2 OEM Models

Due to the sensitivity of the OEM models, it is recommended all ESD, Electrostatic Discharge procedures as outlined in ANSI/ESD S20.20, ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts is followed whenever handling an OEM sensor.

3 Getting Started

- It is recommended to get familiar with the sensor performance and configuration in a controlled environment.
- After unpacking, connect and wire the supplied cabling. Note: with the optional Power Comm Cable, you can power and connect the sensor via the DB9 pin serial connector to a serial I/O device (i.e., USB-to-COM cable on a PC).
- A DB9-to-USB adaptor may be required to connect to many PCs. Make sure the adaptor cable is compatible with your PCs USB specifications.
- To communicate with the sensor, use a terminal emulation program such as Tera Term or HyperTerminal.
- Factory Default Communication Settings: 115200 baud rate, no parity, 8 data bits, 1 stop bit, no flow control.

Measurement Technique

Acquiring a Target

The S300 uses infrared laser light to measure distance. This invisible laser light is emitted from the transmit lens of the sensor, reflects off the liquid surface and returns to the receive lens of the sensor. The exact distance is then calculated by comparing the return time to the speed-of-light constant (Time of Flight).

The ability of a laser sensor to measure to a liquid surface depends on the liquid's reflectance and angle of incident. Reflectance of a liquid is defined by refractive index of the liquid in relationship to reflection angle of the laser. For example, a smooth surface with the laser normal angle of incident is more reflective than a turbulent surface where

the angle of incident varies moment to moment.

The S300 is a highly-sensitive precision laser sensor and can measure to liquid surfaces within its range specification. This includes penetrating through light steam or fog using the Last target mode. A general rule of thumb when measuring through steam or fog is if you can visually see the target, the sensor likely can as well. Remember, humans see in the visible light spectrum whereas the LTI laser sensor utilizes the Infrared wave length (IR) of 905nm. Certain objects will appear differently in the visible spectrum compared to the 905nm wave length, which is why the human eye test is only a general rule of thumb and not an absolute test of what the laser sensor is able penetrate through to the liquid surface.

Liquids & Fluids Application

The S300 series sensor is engineered and specifically designed to directly measure all types of fluids surfaces, including those that are low in reflectivity (such as clear water) and turbulent surfaces. The S300 generates reliable results from the laser's transmitted reflections off the liquid surface that is picked up by the receiver, utilizing complex algorithms, which smooth out the peaks and valleys caused by turbulent fluids surfaces. Because of this, TruSense S300 series will integrate well in static and/or dynamic liquid level monitoring or control systems.

Optional Beam Diffuser

Figure 1: Beam Diffuser

The S300 Diffusing Lens accessory (Part # 7024972) will spread the beam of the laser over a greater area. The diffusing lens will allow the S300 to achieve better results under certain conditions. The diffusing lens in recommended under the following conditions:

- Whenever the range to the target is less than 10 meters.
- Whenever the liquid surface is turbulent during measurement.
- Whenever the beam width is not restricted by the diameter of a stilling pipe.

The S300 Diffusing Lens is not recommended when:

- Measuring a range over 50 meters.
- Whenever a stilling pipe is so narrow over its length that the diameter of the stilling pipe will be less than the diameter of the beam spread (see Table 2).

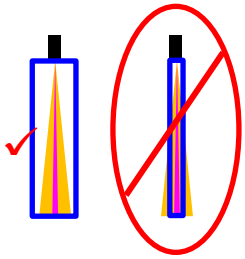
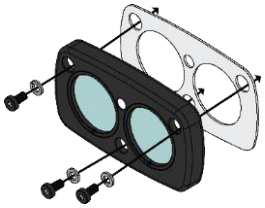


Figure 2: Beam Spread

Mounting the S300 Diffusing Lens

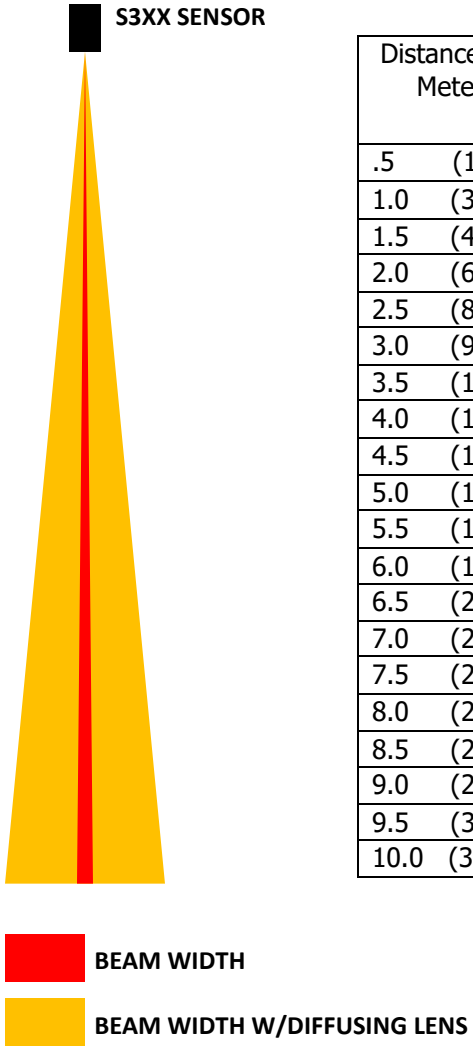


The diffusing lens is attached to the front of the S3xx using the 3 screws provided. A 2mm Allen wrench is included in the diffusing lens package to attach the lens to the TruSense face. Use of the diffusing lens does not compromise the IP rating of the sensor.
The diffusing lens comes with the parts illustrated to the left. Assemble the parts as shown to the front face plate of the sensor.

Figure 3: Diffuser Install

Beam Spread of S3xx Over Distance

The laser beam will spread over distance. The beam spread with increase if the diffusing lens is used. Below is a table to calculate the estimated beam spread at different distances. These calculations should be considered when mounting the sensor against a wall, shooting down a stilling pipe, or where other obstructions could be in the way of the laser beam.



Distance to Target– Meters (Feet)	Beam Width w/o diffuser Meters (Feet)	Beam Width With 2.5 diffuser Meters (Feet)
.5 (1.64)	.025 (.08)	.045 (.14)
1.0 (3.28)	.026 (.08)	.067 (.21)
1.5 (4.92)	.028 (.09)	.088 (.28)
2.0 (6.56)	.029 (.09)	.110 (.35)
2.5 (8.20)	.031 (.10)	.132 (.43)
3.0 (9.84)	.032 (.10)	.154 (.50)
3.5 (11.48)	.034 (.11)	.176 (.57)
4.0 (13.12)	.035 (.11)	.198 (.64)
4.5 (14.76)	.037 (.12)	.219 (.71)
5.0 (16.40)	.038 (.12)	.241 (.78)
5.5 (18.04)	.040 (.13)	.263 (.85)
6.0 (19.69)	.041 (.13)	.285 (.92)
6.5 (21.33)	.043 (.14)	.307 (.99)
7.0 (22.97)	.044 (.14)	.328 (1.06)
7.5 (24.61)	.046 (.15)	.350 (1.13)
8.0 (26.25)	.047 (.15)	.372 (1.20)
8.5 (27.89)	.049 (.16)	.394 (1.27)
9.0 (29.53)	.050 (.16)	.416 (1.34)
9.5 (31.17)	.052 (.17)	.438 (1.41)
10.0 (32.81)	.053 (.17)	.459 (1.48)

TABLE 2: Laser Beam Spread

Beam Diameter at the Target = Free Aperture + (Divergence x Range)

Example:	Distance to the Target	= 100 m
	Divergence	= 3 mrad
	Free Aperture	= 23 mm
	Beam Diameter at the Target	= 0.023 + (0.003 x 100) = 323 mm

Window/Sight Glass Application

When measuring through a window or sight glass, ensure the face plate of the sensor is 3 mm or closer to the window and the laser beam is aligned as close to a normal angle to the window, keeping in mind the liquid surface must be at a normal angle to the laser beam. In addition to distance from the window, reflections will increase with an increased angle to the window in relationship to the laser beam path. Both distance and angle from window could result in measurement errors due to "crosstalk". Crosstalk occurs when the transmitted laser beam is reflected from the window back into the receiver causing inaccurate measurements. To help mitigate crosstalk, place a light baffle between the TruSense transmitter and receiver.

Whenever you are shooting through a glass or plastic material, it is recommended to use materials with high IR (905nm) transmission.

When calculating signal loss due to transmission properties of a window, it is 2x the transmission (Transmission Loss outbound + Transmission loss inbound).

Foam Application

The laser will likely measure to the top of the foam if present. However, the use a stilling well or by-pass pipe can mitigate this condition. These devices allow the fluids to enter through perforations and reach the same level as the rest of the vessel but reducing the amount of agitation and foam that may be present outside of the stilling well. Another technique to counter foam is to create a small "wash-down" area at the side of the tank which will clear a small area through the foam, down to the material layer. Shoot the laser at this spot.

If both the foam layer and the below liquid surface layer are required to be monitored, two separate TruSense S300 models can be set up to provide both measurements. For example, one can be used inside a stilling well and the other outside to measure both targets.

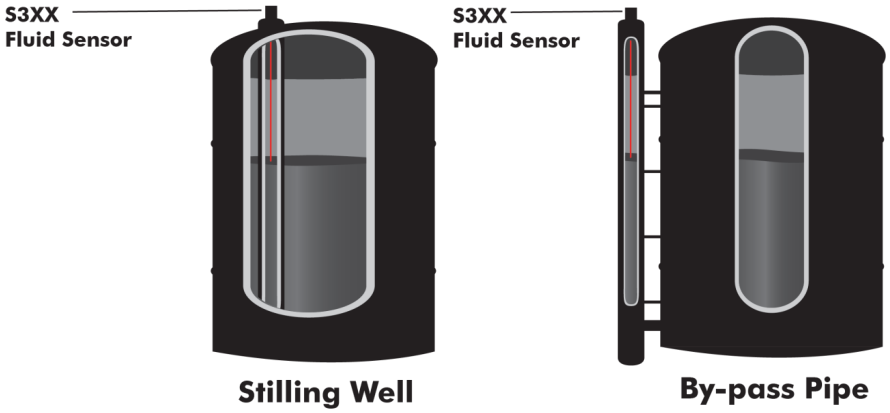


Figure 4: Stilling/By-Pass

Dense Steam Application

The presence of steam is a particularly challenging condition. Like most scenarios it depends on the density & composition of the steam and the nature of the surface to be measured (still or turbulent). A general rule of thumb is that if you can see through the steam to the liquid surface, the laser should be able to as well.

Transmit Receive Lens

Left side referencing the front view as shown in the figure to the right.

Measurement Reference

Distance measurements are from the sensor front plate to the target as shown in the figure to the right. Note: The zero point will change slightly due to Diffuser lens, Window (if present) and/or mounting environment. For these reasons a User's Offset can be programmed into the TruSense to set the zero point.

Hazardous Locations

It is recommended to use the Ruggedized Housing Enclosure designed to house the S300 (see Appendix A of the document for more information). This can be mounted to an adaptor and flange for easy installation in a tank or silo. A dust tube will attach to the adaptor and provides an ¼ X 18 NPT access for an air tube to provide positive air pressure inside the tube for dusty environments.

Sunlight

If installing the TruSense sensor outdoors, it is important not to allow direct sun to shine on the sensor. Direct sun light can raise temperatures above the safe operating temperature of the sealed TruSense sensor causing a thermal shutdown of the sensor until sensor returns to normal operating temperatures.

4 Initial Setup Requirements

Electrical

Recommend 12-24 volt dc.

I/O

Default RS-232 Communication (found on all models) = 115200 baud rate, no parity, 8 data bits, 1 stop bit, no flow control.
Note: other I/O available, depending on model.

Mounting

Mounting slots are 4 X 3.2mm (0.13 inches), always use a washer and do not exceed 5-I nch pounds of torque when securing. Recommended bolt size is M3, or 4-40.

Alignment

To get best performance from the TruSense S3xx, it is important to setup the sensor to be as close to 90 degrees to the liquid surface (+/-2 degrees).
There are two methods to orient the sensor to the surface of the liquid, aligning with a bubble level or signal strength return displayed via the RS-232 communication.

1. Bubble level alignment: During manufacturing, the TruSense laser beam is precisely aligned to the outer body of the TruSense sensor. Placing a level on the back plate or sides of the sensor will allow a method to assure the sensor is in the correct downward orientation. Note: For OEM sensor the front face plate is orientated 90 degrees to the laser beam.
2. Signal Strength Return: This method will require a Laptop Windows computer with a RS-232 Com Port attached to the TruSense sensor and a Terminal communication

program like Tera Term or Hyper Term. The TruSense S300-series sensor will output a signal strength reading from 0-2000 where 2000 indicates the strongest return. By orientating the sensor, the goal is to peak the signal strength to the highest value possible. The power return value above 1000 is considered excellent.

5 RS-232 ASCII Serial Communication Protocol

RS-232 communication is available in all the S3xx models. This communication pathway can be used for setting, controlling and configurating the sensor.

- Each command line and reply line begins with a '$' sign and ends with *CRC16 <CR><LF>. Note: CR is carriage return and LF is line feed.
- RS-232 factory default communication parameters: baud rate 115200, no parity, 8 data bits, 1 stop bit, no flow control.
- There are four types of RS-232 commands: Get, Set, Get & Set, and Direct Action.
- On commands that have the 'Get' function, issuing a command without an associated parameter(s), prompts the S3xx to reply with the current setting of that parameter(s). Example: Sent: *$,<Command><CR><LF>* Return: *$,<Command>,<Parameter> * CRC16*
- On commands that have the 'Set' function, issuing the command as followed: *$,<Command>,<Parameter Value> <CR><LF>*. Some commands have multiple parameters that can be set which would be separated by additional ','. Example: *$,<Command>,<1st Parameter Value>,<2nd Parameter Value>…… <CR><LF>*. Note: Additional characters to the right of the parameter(s) are ignored.
- On direct action commands, issuing the command will be executed directly after the <CR><LF> is sent. Example: *$,<Command><CR><LF>*

Note: Each command is made up of two alpha characters that are not case sensitive.

Important: Before entering any command, issue the Stop command (Direct Action command) Example: ***$ST****<CR><LF>.*

Important: After changing any Set command parameters, to permanently save in non-volatile memory, the Save command (Direct Action command) ***$SU****<CR><LF>* must be executed. Note: After execution the sensor will save current settings and reboot.

- When first applying power, the unit performs an initialization and onboard self-test to ensure the sensor systems pass.
- Thre are three methods for initiating a measurement:
- Serial command request (see $GO command).
- Auto start at boot-up (see $MA command).
- Hardware control via the Ext-Trig control signal (see $TG command).
- The time for an individual measurement will vary depending on liquid mode settings, warm up time, and update period. For more detailed information see Section 7.

Factory Default Settings

Note: For detailed information on RS-232 ASCII Commands for setting up sensor, see Section 7.

		S300	S310	S330
Command Description	**Command**	**Settings**	**Settings**	**Settings**
Baud Rate	BA	115200	115200	115200
Consecutive Errors	CE	5	5	5
Display Banner	DB	0	0	0
Error Code Output Format	DE	0	0	0
HS Intensity	DI	1	1	1
Target Mode	DM	5	5	5
HS Time Display	DT	0	0	0
4-20mA Setting	FT	0.000,10.000,0.0, 1,1,0,0,0,0	0.000,10.000,0.0, 1,1,0,0,0,0	0.000,10.000,0.0, 1,1,0,0,0,0
Auto-Start Measurement Mode	MA	1	1	1
Measurement Mode	MM	4	4	4
Measurement Units & Resolution	MU	M,3	M,3	M,3
Generate Errors	NE	0	0	0
Liquid Filter	OS	2,1,0,0	2,1,0,0	2,1,0,0
External Trigger Gates	RD	1,10	1,10	N/A
External Trigger Mode	TG	5	5	0
User Offset	$UO	0	0	0
Visible Laser Pointer off	$VF	N/A	Yes	Yes

Table 2: Factory Default

6 4-20mA Loop Setup

This section will cover the setup of the TruSense sensor for a 4-20mA installation using the RS-232 ASCII communication. The TruSense sensor is configured from the factory to measure most liquid measurement situations out of the box. Since the S330 is a smart sensor, to implement the 4-20mA loop, the user need only define the loop boundaries and empty current (Item 2 under the Programing the S330 section). The user can setup the sensor at a bench prior to installation or at the working location. By answering the below question and programing the sensor with the RS-232 ASCII serial commands, the sensor should be ready to integrate into your level measurement system.

Before you start you will need:

1. The TruSense S330 is not loop powered so a 12-24DC power and ground needs to be at the sensor location in addition to the powered current loop supply and return wires.
2. Open 4-20mA receiver on a PLC.
3. Vessel height from Empty to Full level (Measurement Span). Typically, this would be to overflow pipe.
4. The distance from sensor mounting point to the Full level of vessel (Instrument Offset).
5. If your PLC accepts error current signal, what current values are available.
6. Available COM port on the programing PC.

7. TruSense Power COM cable or equivalent.
8. Terminal program like Tera Term or HyperTerminal.

Note: Terminal communication parameters: baud rate 115200, no parity, 8 data bits, 1 stop bit, no flow control.

Programing the S330

1. Measurement Units ($MU)

This will setup the instrument measurement units for all measurement communication formats. For liquid measurements, the available options are feet or meters. In addition to setting measurement units, you can specify how many decimal places to display in the RS-232 data export.
Note: Decimal place setting has no effect on the current loop resolution.

1.1. What measurement unit are you using?

- Meters, two decimals? Serial Command: $MU,m,2<Return>
- Meters, three decimals? Serial Command: $MU,m,3<Return>
- Feet, two decimals? Serial Command: $MU,f,2<Return>
- Feet, three decimals? Serial Command: $MU,f,3<Return>

Note: See Serial Command $MU for more information.

2. Setting the Current loop boundaries and error current. ($FT)

The following questions will setup the $FT serial command parameters, 4mA boundary, 20mA boundary, and error current (Refer to Figure 5).

2.1. What is the Measurement Span of the vessel (Vessel Height)?
2.2. What is the Instrument Offset?
2.3. What is the Error Current setting?
2.4. What is Distance Span (Instrument Offset + Measurement Span)?
2.5. What is Distance Span current boundary? 4mA or 20mA
2.6. What error current do you need?

3. Liquid sensing setup. ($OS)

This command controls the filtering type, measurements per second, advance noise filter, and running average. See serial command $OS for more information.

3.1. What filtering types do you need for the liquid surface you are measuring to?
3.1.1. Smooth Surface = 1
Note: The Smooth filter works in environments with smooth surfaces, producing a slightly more accurate reading.
3.1.2. Turbulent = 2
Note: The Turbulent filter should be used in environments that can transition from smooth to turbulent or are always turbulent.
3.2. Measurements per Second.
3.2.1. Available 1 to 14.
Note: Only set greater than 1 if your system requires faster than one second updates to the current loop.
3.3. Advanced noise Is always set to 0.
3.4. What Running Average do you need?
3.4.1. Available options are 0(off) and from 2 seconds to 30 seconds in whole second intervals.

4. Error Reporting. ($CE and $NE)
   Error reporting can be turned on or off ($NE). An enhanced feature is the addition of consecutive error reporting. During turbulent surface condition momentary single return losses can occur. By setting this, you can account for this condition and only report error that are true in nature.
   Note: For more information see serial commands $CE and $NE.
   - 4.1. Do you error reporting?
     - 4.1.1. Yes $NE,0 (On)
     - 4.1.2. No $NE,1 (Off)
   - 4.2. What kind of liquid surface is most common?
     - 4.2.1. No Turbulence $CE,3
     - 4.2.2. Slight Turbulence $CE,10
     - 4.2.3. Moderate Turbulence $CE,100
     - 4.2.4. Very Turbulence $CD,255

     Note: Any whole number between 1 to 255 can work but the above values work in most cases.

5. Sensing Environment ($DM)
   The TruSense sensor can identify multiple targets, if found. In stilling wells, light steam or fog the last target reporting will mitigate the possibility of early returns from these obstacles.
   Note: For more information see serial command $DM

   5.1. What measurement conditions?
   - 5.1.1. Open vessel $DN,5 (First Target)
   - 5.1.2. Stilling well $DM,7 (Last Target)

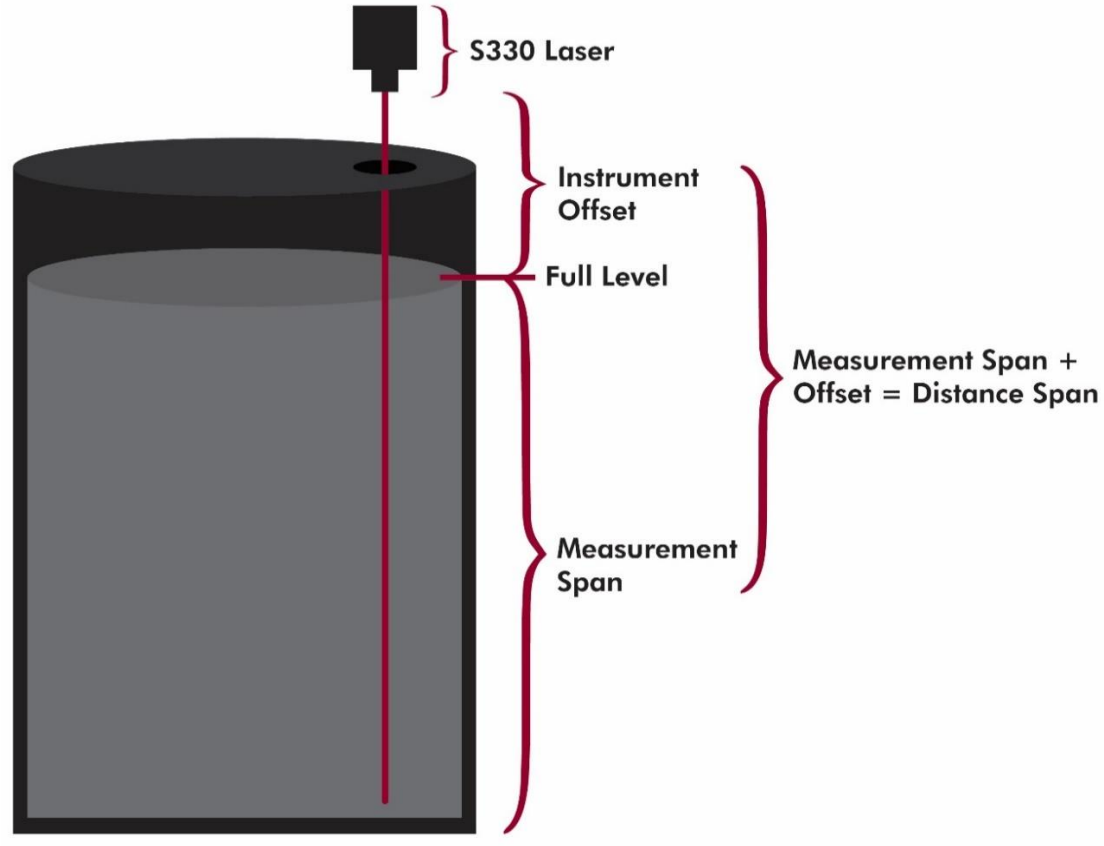


Figure 5: Vessel 4-20 Setup

7 4-20mA Work Sheet

The following Work Sheet can be printed out and used to build ASCII serial command and record the sensor settings for future reference. The intent of this worksheet is to allow the user to build each ASCII serial command for the 4-20mA loop.

Work Sheet for setting TruSense S330 for installation in 4-20mA Loop

Sensor Serial Number: _____ Sensor Location: _____

	Measurement unit $MU	**Question**	
1		Meters, two decimals?	$MU,m,2 ☐
		Meters, three decimals?	$MU,m,3 ☐
		Feet, two decimals?	$MU,f,2 ☐
		Feet, three decimals?	$MU,f,3 ☐
		ASCII Command	**ASCII Command to send**
		$MU,_____,_____	$MU,<Line1>
	Current Loop $FT	**Question**	
2		Measurement Span Height?	
3		Instrument Offset Height?	_____
4		Distance Span Calculation	<Line5> + <Line 6> =_____
5		4mA Current boundary?	Distance Span or Instrument offset Value: _____
6		20mA Current boundary?	Distance Span or Instrument offset Value: _____
7		Error Current?	0 = Loop out of bounds error current 24mA ☐
			1 = Loop out of bounds error current 3.5mA ☐
		ASCII Command	**ASCII Command to send**
		$FT,_____,_____,0,_____,1	$FT,<Line 5 >,<Line 6>,0,<Line7>,1
	Liquid Setting $OS	**Question**	
8		What Filter Type?	Smooth Surface = 1 ☐
			Turbulent Surface = 2 ☐
9		Measurement per second?	Value 1 to 14: _____
10		Running Average?	Value 0=off 2-30 = on:_____
		ASCII Command	**ASCII Command to send**
		$OS,_____,_____,0,_____	$OS,<Line8 >,<Line 9>,0,<Line 10>
	Error Reporting $NE	**Question**	
11		Error Reporting?	On = 0 ☐
			Off = 1 ☐
		ASCII Command	**ASCII Command to send**
		$NE,_____	$NE,<Line 11>
	Consecutive Errors $CE	**Question**	
12		Consecutive Errors?	No Turbulance = 3 ☐
			Slight Turbulance = 10 ☐
			Moderate Turbulance = 100 ☐
			Very Turbulant = 255 ☐
		ASCII Command	**ASCII Command to send**
		$CE,_____	$CE,<Line 12>
	Target Mode $DM	**Question**	
13		Target Mode?	Open Vessel = 5 ☐
			Stilling Well = 7 ☐
		ASCII Command	**ASCII Command to send**
		$DM,_____	$DM,<Line13>

8 RS-232 ASCII Measurement Output Messages

This section defines the RS-232 ASCII measurement output format. For detailed information on RS-232 ASCII Commands for setting up sensor, see Section 7.

First Target

Output message if $DI = 0 (Intensity Off) and $DT = 0 (Time Stamp Off)
$DF,<distance> *CRC16**<CR><LF>**

Example: $DF,1.39*7321<CR><LF>

Output message if $DI = 0 (Intensity Off) and $DT = 1 (Time Stamp On)
$DF,<distance>,< since power on>*CRC16**<CR><LF>**

Example: $DF,1.40,3.236*35E4

Output message if $DI = 1 (Intensity On) and $DT = 0 or 1 (Time Stamp Off or On)
$DF,<distance>,< time stamp on>,<Power Return>*CRC16**<CR><LF>**

Example: $DF,1.40,8.678,1543*C392

Strongest Target

Output message if $DI = 0 (Intensity Off) and $DT = 0 (Time Stamp Off)
$DS,<distance> *CRC16**<CR><LF>**

Example: $DS,1.38*76E2<CR><LF>

Output message if $DI = 0 (Intensity Off) and $DT = 1 (Time Stamp On)
$DS,<distance>,< time stamp on>*CRC16**<CR><LF>**

Example: $DS,1.38,8.653*43C6<CR><LF>

Output message if $DI = 1 (Intensity On) and $DT = 0 or 1 (Time Stamp Off or On)
$DS,<distance>,< time stamp on>,<Power Return>*CRC16**<CR><LF>**

Example: $DS,1.38,2.396,1430*CF7B<CR><LF>

Last Target

Output message if $DI = 0 (Intensity Off) and $DT = 0 (Time Stamp Off)
$DL,<distance> *CRC16**<CR><LF>**

Example: $DL,1.38*19E0<CR><LF>

Output message if $DI = 0 (Intensity Off) and $DT = 1 (Time Stamp On)
$DL,<distance>,< time stamp on>*CRC16**<CR><LF>**

Example: $DL,1.40,6.767*BCE2<CR><LF>

Output message if $DI = 1 (Intensity On) and $DT = 0 or 1 (Time Stamp Off or On)
$DL,<distance>,< time power on>,<Power Return>*CRC16**<CR><LF>**

Example: $DL,1.40,7.023,1420*6142<CR><LF>

9 RS-232 ASCII Serial Commands

This section defines the individual ASCII commands for setting up and controlling measurement over the RS-232 communication pathway.

$AU Display Board AUX Board Status

Gets AUX board information that defines Visible laser pointer and additional communication pathways.

Get: **$AU<CR><LF>**
Instrument Reply: $AU,<aux board configuration>,<working aux configuration>,<factory setting>*CRC16**<CR><LF>**

The S300 gives actual aux board configuration as well as working configuration. Normally, actual configuration is same as working one, but some function is disabled if there is conflict. If Actual configuration sets a bit for the wrong setting, S300 may not work correctly. All configurations are hexadecimal digits. See below bit description:

- S300 SDI-12; No Visible Laser Pointer Response: *$AU,0x0,0x10,0x10*5DEB*
- S310 SDI-12; Visible Laser Pointer Response: *$AU,0x9,0x1,0x11*9053*
- S330 4-20mA; Visible Laser Pointer Response: *$AU,0x7,0x7,0x7*F0B4*

Example: Input: Get $AU<CR><LF>
Reply: $AU,0x7,0x7,0x7*F0B4<CR><LF>

$BA RS232 Baud Rate

Sets and gets the serial communications data rate. The reply message to this command is sent at the previous baud rate. Default baud value = 115200 .
Important: Once $PD is issued, the user must configure communication link to new Baud Rate.

Set: **$BA,***n***<CR><LF>** Instrument Reply: ***$BA,****n**CRC16**<CR><LF>***
TO SET NEW BAUDRATE, USE $PD OR POWER CYCLE

Get: **$BA<CR><LF>** Instrument Reply: ***$BA,****n**CRC16**<CR><LF>***

where:
$ = message identifier
BA = mnemonic for RS232 Baud Rate
n = baud rate: 9600, 19200, 38400, 57600, 115200, 230400

*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: Get $BA<CR><LF>
Reply: $BA,115200*6FC3<CR><LF>
TO SET NEW BAUDRATE, USE $PD
Input: Set $BA,4800<CR><LF>
Reply: $BA,4800*3A67 <CR><LF>
TO SET NEW BAUDRATE, USE $PD

$CE Number of Consecutive Errors Before Reporting for Liquid Measurement

This command is used to fine tune the measurement errors to report. Measuring to turbulent liquid surfaces can produce momentary loss of laser return signal that can cause incomplete measurement calculation. By increasing this value, it will report only errors true in nature.

Set: $CE,n<CR><LF> Instrument Reply: $CE,n*CRC16<CR><LF>
Get: $CE<CR><LF> Instrument Reply: $CE,n*CRC16<CR><LF>

where:
- **$** = message identifier
- **CE** = mnemonic for Consecutive Errors
- *n* = Number of Consecutive errors
  - 0 = off
  - 1 to 255 consecutive errors
- *CRC16 = 16-bit CRC
- **<CR>** = carriage return
- **<LF>** = line feed

Example:
Input: Get $CE,<CR><LF>
Reply: $CE,10*8E84<CR><LF>
Input: Set $CE,10<CR><LF>
Reply: $CE,10*8E84<CR><LF>

$CL Convert Error Code to Error Message

This is user informational for each valid error message.

Get: **$CL,**n**<CR><LF>**
Instrument Reply: **$ER,***n,message**CRC16**<CR><LF>**

where:
- **$ CL** = message identifier
- N = mnemonic for Convert Error Code to Error Message
- Message = the error code
- *CRC16 = the error message
- = 16-bit CRC
- **<CR>** = carriage return
- **<LF>** = line feed

Example:
Input: Get $CL,1<CR><LF>
Reply: $ER,01,NO TARGET*EC78<CR><LF>

$CO Display $GO Command Parameters

This function is typically used in RS-232 Communication when a fixed number of measurements are required over a fixed time interval. To set, see the $GO command.
Important: For the TruSense S3xx, the $OS command should be used with the $GO to set the time interval instead of the second parameter of the $GO command.

Get: **$CO<CR><LF>**
Instrument Reply: **$CO,**<mode>,<number of iteration>,<update period>CRC16**<CR><LF>**

where:
- **$** = message identifier
- **CO** = mnemonic for Display $GO Command Parameters

Mode
number of iterations

update period
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: Get $CO<CR><LF>
Reply: $CO,1,1,1.0*25CF<CR><LF>

$DB Display Banner

When the Banner is enabled, if no errors are encountered, a sensor informational banner will be displayed when the unit is powered on based on the model:

TruSense S300
TruSense S300 Series,DS-300-1.14 PRF[1000/2800] [CP-WP-U-UL]
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TruSense S310
TruSense S300 Series,DS-310-1.14 PRF[1000/2800] [CP-WP-U-UL]
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TruSense S330
TruSense S300 Series,DS-330-1.14 PRF[1000/2800] [CP-WP-U-UL]
(c) 2010-2018 Laser Technology Inc. All rights reserved.

Note: If the Banner is disabled and an error is encountered when the unit is powered ON, the appropriate error code will be displayed.

Set: **$DB,***n***<CR><LF>** Instrument Reply: **$DB,***n**CRC16**<CR><LF>**
Get: **$DB<CR><LF>** Instrument Reply: **$DB,***n**CRC16**<CR><LF>**

where: **$** = message identifier
DB = mnemonic for Display Banner
n = display banner status
0 = Banner is disabled
1 = Banner is enabled
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: Get $DB<CR><LF>
Reply: $DB,1*F069<CR><LF>
Input: Set $DB,0<CR><LF>
Reply: $DB,0*30A8<CR><LF>
Input: Set $DB,1<CR><LF>
Reply: $DB,1*F069<CR><LF>

$DE Error Code Format

This commands sets the display error code or error code plus error description.

Set: **$DE,***n***<CR><LF>** Instrument Reply: **$DE,***n**CRC16**<CR><LF>**
Get: **$DE<CR><LF>** Instrument Reply: **$DE,***n**CRC16**<CR><LF>**

where: **$** = message identifier
DE = mnemonic for Display Error Code
n = display Error Code status
0 = Display Error Code Only
1 = Display Error Code with Mnemonic

*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example:

Input: Get	$DE<CR><LF>
Reply:	$DE,0*F119<CR><LF>
Input: Set	$DE,0<CR><LF>
Reply:	$DE,0*F119<CR><LF>
Input: Set	$DE,1<CR><LF>
Reply:	$DE,4*3218<CR><LF>

$DI Display Return Intensity

This command will display the intensity of the returning single. The scale is from 1 to 2000 where 2000 is the strongest and 1 is the lowest insensitivity return. Power Return Intensity scale is as follows:

- Power intensity greater or equal to 1000 = Excellent
- Power intensity from 700 to 1000 = Good
- Power intensity from 400 to 699 = Fair
- Power intensity less than 400 = Poor

Set: **$DI,*n*<CR><LF>** Instrument Reply: **$DI,*n***CRC16**<CR><LF>**
Get: **$DI<CR><LF>** Instrument Reply: **$DI,*n***CRC16**<CR><LF>**

where:
$ = message identifier
DI = mnemonic for Display Error Code
n = display Error Code status
0 = Do not Display Intensity
1 = Display Intensity
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example:

Input: Get	$DI<CR><LF>
Reply: if Off	$DI,0*F2D9<CR><LF>
Reply: if On	$DI,256*93EC<CR><LF>
Input: Set	$DI,0<CR><LF>
Reply:	$ $DI,0*F2D9<CR><LF>
Input: Set	$DI,1<CR><LF>
Reply:	$DI,256*93EC<CR><LF>

$DM Target Mode

The TruSense S300 series can detected multiple targets if present. This command allows the user to choose which target to report.
Important: The TruSense S3xx, the $MM (Measurement Mode) must be set to 4 (Liquid Measurement Mode) for the following $DM parameters to be valid.

First Target
The measurement output represents the distance to the first valid target the sensor identifies. If only one target is found, it will report this target. This is factory default setting.

Strongest Target

The measurement output represents the distance to the strongest valid target the unit identifies.

Last Target
The measurement output represents the distance to the last valid target the unit identifies. If only one target is found, it will report this target. This is useful when installed in a stilling well or close to a side wall of containment vessel.

Set: $DM,*n*<CR><LF> Instrument Reply: **$DM,***n**CRC16**<CR><LF>**
Get: $DM<CR><LF> Instrument Reply: **$DM,***n**CRC16**<CR><LF>**

where:
$ = message identifier
DM = mnemonic for Display Mode
n = target mode
5 = First Target
6 = Strongest Target
7 = Last Target
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example:
Input:Get $DM<CR><LF>
Reply: $DM,5*3058<CR><LF>
Input:Set $DM,6<CR><LF>
Reply: $DM,6*3118<CR><LF>

$DT Display Time

When in $MM,4 (Liquid Measurement mode) the time stamp counts from 0 to 9.999 seconds before rolling back to zero.

Set: **$DT,*n*<CR><LF>** Instrument Reply: **$DM,***n**CRC16**<CR><LF>**
Get: **$DT<CR><LF>** Instrument Reply: **$DM,***n**CRC16**<CR><LF>**
where:
$ = message identifier
DT = mnemonic for Display Mode
N = Display Time
0 = Do not Display Time
1 = Display Time
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example:
Input: Get $DT<CR><LF>
Reply: if off $DT,0*F449<CR><LF>
Reply: if on $DT,2*35C8<CR><LF>
Input: Set $DT,0<CR><LF>
Reply: DT,0*F449<CR><LF>
Input: Set $DT,1<CR><LF>
Reply: $DT,2*35C8<CR><LF>

$FT 4-20 Current Loop Setting

This command is to set all functionality of the 4-20mA current loop.

Set: **$FT,**<value for 4mA>,<value for 20mA>,<update period>, <error handling>, <number of measurements>**<CR><LF>**

Instrument Reply: **$FT,**<value for 4mA>,<value for 20mA>,<update period>, <error handling>,
<number of measurements>,[n,n,n,n]**<CR><LF>**

Get: **$FT<CR><LF>**

Instrument Reply: **$FT,**<value for 4mA>,<value for 20mA>,<update period>, <error handling>,
<number of measurements>,[n,n,n,n]**<CR><LF>**

where:

$	= message identifier	
FT	= mnemonic for Current Loop Setting	
Value for4 mA	= 4mA Boundary in	$MU Units
Value for20 mA	=20mA Boundary in	$MU Units
Update period	= always 0	Use $OS command 4th parameter.
Error handling	=0	distance is out of bounds, set current loop to 24mA and sensor measurement error set current loop to 24mA.
	=1	distance is out of bounds, set current loop to 3.5mA and sensor measurement error, set current loop to 3.5mA.
	=239	distance is out of bounds, keep the previous value and sensor measurement error, set current loop to 3.5mA.
	=240	distance is out of bounds 4mA, set 3.5mA. If it is out of 20mA, set 24mA and sensor measurement error set current loop to 3.5mA.
Number of measurements	= Always 1	Used the $OS command fourth parameter.
[n,n,n,n]	=Not used	This functionality is not used in Liquid Measurement mode.
*CRC16	= 16-bit CRC	
<CR>	= carriage return	
<LF>	= line feed	

Example:

Input: Get	$FT<CR><LF>
Reply:	$FT,3.080,0.080,0.0,1,1,[0,3,4,5]*194A<CR><LF>
Input: Set	$$FT,3.080,0.080,0.0,1,1<CR><LF>
Reply:	$FT,3.080,0.080,0.0,1,1,[0,3,4,5]*194A <CR><LF>

$GO Start Distance Measurement

This command starts the sensor measuring.

Note: This command functions the same as using the trigger input connection based on the Ext-Trig ($TG,2 or 3) setting (Active high/Active low). This trigger input connection is only available in the TruSense S300 and S310.

Set: **$GO <CR><LF>** Instrument Reply: **$OK***CRC16**<CR><LF>**

Note: Number of measurements and update period based on $CO settings.

Set: **$GO**,*n*,*m***<CR><LF>** Instrument Reply: **$OK***CRC16**<CR><LF>**

where:
$ = message identifier
GO = mnemonic for Start Distance Measurement
n = number of measurements
0 = continuous Note: Must issue $ST command to stop
1 = one measurement
2 = two measurements, etc
m = update period
*CRC16 = 16-bit CRC
<CR> = carriage return

Example:
Input: Set $GO<CR><LF>
Reply: $OK*0774<CR><LF>
Note: Timing defined by the $CO command
Input: Set $GO,1,1<CR><LF>
Reply: $OK*0774<CR><LF>

IMPORTANT: For the TruSense S3xx, the $OS command should be used instead of the second parameter of the $GO command for setting time interval.

Note: <number of measurements>,<update period> are stored in volatile memory. To save in non-volatile memory, save with $SU or $PD command.

$ID Instrument Identification

Get: **$ID<CR><LF>**
Instrument Reply: **$ID,**DS-3xx TruSenseS300-version-build number, firmware date, 4E62F63C*A8CD**<CR><LF>**

where:
$ = message identifier
ID = mnemonic for firmware version information
DS-3xx = product model
TruSenseS300 = product model
-version = firmware version
firmware date = firmware date
4E62F63C = firmware checksum
*A8CD = command string checksum
<CR> = carriage return
<LF> = line feed

Example:
Input: Get $ID<CR><LF>
Reply:
$ID,DS-330,TruSense S300 Series-1.14-113,JAN 14 2019,11F14194*406F

$IS Instrument Status

Get: **$IS**<CR><LF>
Instrument Reply: **$IS**,<run flag>, <system error status><password status>*CRC16<CR><LF>

where: **$** = message identifier
IS = mnemonic for Instrument Status
run flag = laser status
0 = laser is not firing
1 = laser is firing
system error status = system status
0= normal operation Error code.
password status = password status
0 = Password is enabled:
User Commands that require password are prohibited and will result in an error.
1 or 2 = Password is disabled:
All user commands are allowed.
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: Get $IS<CR><LF>
Reply: $IS,0,0,1*7C35

$MA Manual Start

This command determines the status of the laser after the unit is powered ON and initialized.

Set: **$MA,***ma***<CR><LF>** Instrument Reply: **$MA,***ma**CRC16**<CR><LF>**
Get: **$MA<CR><LF>** Instrument Reply: **$MA,***ma**CRC16**<CR><LF>**

where: **$** = message identifier
MA = mnemonic for Manual Start
ma = Manual Start status
0 = Manual Start is active:
Enter $GO command to fire laser.
Non-Zero = Automatic Start is active:
Laser starts to fire immediately after power ON and initialization.
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: Get $MA<CR><LF>
Reply: off $MA,0*AC5B
Input: Get $MA<CR><LF>
Reply: on $MA,2*6DDA
Input: Set $MA,0<CR><LF>
Reply: off $MA,0*AC5B
Input: Set $MA,1<CR><LF>
Reply: on $MA,2*6DDA

$MM Measurement Mode

For liquid applications $MM should always be set to 4. **IMPORTANT:** If $MM is not set to 4, incorrect operation of sensor will occur.

Set: **$MM,***n* **<CR><LF>** Instrument Reply: **$MM,**n*CRC16**<CR><LF>**
Get: **$MU<CR><LF>** Instrument Reply: **$MM**,n*CRC16**<CR><LF>**

where:
- **$** = message identifier
- **MM** = mnemonic for Measurement Units
- N = measurement mode
  - 0 to 2= Do not use
  - 4 = Liquid measurement mode
- *CRC16 = 16-bit CRC
- **<CR>** =carriage return
- **<LF>** = line feed

Example:

Input: Get $MM<CR><LF>
Reply: $MM,4*6C9A<CR><LF>

Input: Set $MM,4<CR><LF>

Reply: $MM,4*6C9A<CR><LF>

$MU Change Measurement Unit

This command is used to change the measurement units. Factory default is meters and three decimal places.

Set: **$MU,***u,*n **<CR><LF>** Instrument Reply: **$MU,**u,nn,K,MM*CRC16**<CR><LF>**
Get: **$MU<CR><LF>** Instrument Reply: **$MU**,u,nn,K,MM*CRC16**<CR><LF>**

where:
- **$** = message identifier
- **MU** = mnemonic for Measurement Units
- u = measurement units
  - 0 or m = meters
  - 1 or f = feet
- n = Number of places after decimal point. Max = 3
- K = Not used in Liquid mode.
- MM = Not used in Liquid mode.
- *CRC16 = 16-bit CRC
- **<CR>** = carriage return
- **<LF>** = line feed

Example:

Input: Get $MU<CR><LF>
Reply: $MU,F,33,K,11*35B0<CR><LF>

Input: Set $MU,F,3<CR><LF>

No Changes to current settings

Reply: $MU,F,33,K,11*35B0<CR><LF>

Input: Set $MU,M,2<CR><LF>

Changes to current settings with Banner turned on $DB,1
Reply: TruSense S300 Series,DS-330-1.14

PRF[1000/2800] [CP-WP-U-UL]
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$READY

Input: Set $MU,F,3<CR><LF>

Changes to current settings with Banner turned off DB,0

Reply: Sensor Reboots with no reply

$NE Error Reporting on/off

This command will turn off or on error reporting the liquid measurement mode.

Set: $NE,n**<CR><LF>** Instrument Reply: $NE,n*CRC16**<CR><LF>**
Get: $NE **<CR><LF>** Instrument Reply: $NE,n*CRC16**<CR><LF>**

where:
- **$** = message identifier
- **NE** = mnemonic for Error Reporting
- *n* = display Error Code status
  - 0 = Display Error
  - 1 = Do Not Display Error
- *CRC16 = 16-bit CRC
- **<CR>** = carriage return
- **<LF>** = line feed

Example:

Input: Get $NE<CR><LF>
Reply: $NE,0*291A<CR><LF>

Input: Set $NE,0<CR><LF>

Reply: $NE,0*291A<CR><LF>

$OS Liquid Setup Command

This command controls the filtering type, measurements per second, advance noise filter, and running average. Filtering types available are low pass and median. The Low pass filter works in environments with smooth surfaces, producing a slightly more accurate reading. The Median filter should be used in environments that can transition from smooth to turbulent or are always turbulent. Advanced noise filter is reserved for custom application. Running average will smooth out readings in dynamic surface conditions.

Set: $OS,f,s,a,r<CR><LF> Instrument Reply: $OS,f,s,a,r*CRC16<CR><LF>
Get: $OS<CR><LF> Instrument Reply: $OS,f,s,a,r*CRC16<CR><LF>

where:
- **$** = message identifier
- **OS** = mnemonic for liquid command
- f = filter mode
  - 1 = low pass
  - 2 = median
- s = measurement output per second
  - Valid settings are 14 to 1
- a = Advance noise always set to 0
- r = Running average
  - 0= off
  - 2 to 30 = on
- *CRC16 = 16-bit CRC
- **<CR>** = carriage return
- **<LF>** = line feed

Example: Input: Get $OS<CR><LF>
Reply: $OS,1,1,0,0*BA96<CR><LF>
Input: Set $OS,2,1,0,4<CR><LF>
Reply: $OS,2,1,0,4*79A4<CR><LF>

$OZ Instrument Temperature

This command will display the internal temperature of the sensor

Get: **$OZ<CR><LF>**

Instrument Reply: **$OZ,***n**CRC16**<CR><LF>**

where:
- **$** = message identifier
- **OZ** = mnemonic for Instrument Temperature
- *n* = instrument temperature (degrees Celsius)
- *CRC16 = 16-bit CRC
- **<CR>** = carriage return
- **<LF>** = line feed

Example: Input:Get $OZ<CR><LF>
Reply: $OZ,35.6*04A1

$PD Power Down and Restart Unit

Send this command after changing the communication baud rate. The instrument will power down and restart using the new baud rate.

Direct Action: **$PD<CR><LR>**

where:
- **$** = message identifier
- **PD** = mnemonic for Power Down and Restart
- **<CR>** = carriage return
- **<LF>** = line feed

Example: Input: $PD<CR><LF>
Display Banner Turned off $DB,0
Reply: $PD,BY COMMAND*7BB1
Input: $PD<CR><LF>
Display Banner Turned on $DB,1
Reply: $PD,BY COMMAND*7BB1

TruSense S300 Series,DS-330-1.14
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$READY

$PE Set Update Period

The TruSense S300 series can be set up to measure periodically. For example, if 10 measurements are required every 20 seconds, set update period as 20. This command should be set to zero. Always use the $OS command for measuring liquids.

Set: $PE,n<CR><LF> Instrument Reply: $OK*CRC16<CR><LF>
Get: $PE<CR><LF> Instrument Reply: $PE,n*CRC16<CR><LF>

where: $ = message identifier
PE = mnemonic for Set Update Period
n = update period (Number of seconds. Accepts decimal point.)
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: Get $PE<CR><LF>
Reply: $PE,0.0*B4D4<CR><LF>
Input: Set $PE,0<CR><LF>
Reply: $PE,0.0*B4D4<CR><LF>

Note: The Update Period is stored in volatile memory. Use **$SU** or **$PD** to store the Update Period into non-volatile memory.

$PW Enter Password

This command is to unlock password protected commands to allow editing. Note: Factory default, password is disabled.

Set: $PW,*pw*<CR><LF> Instrument Reply: $PW,x*CRC16<CR><LF>

where: $ = message identifier
PW = mnemonic for Trip Distance
pw = Current password
x = Lock status response
0= Password enforced
1 = Password not enforced
<CR> = carriage return
<LF> = line feed

Example: Input: Set $PW<CR><LF>
Reply: $PW,0*04BC<CR><LF>
Input: Set $PW,NO_PASSWORD<CR><LF>
Reply: $PW,1*C47D<CR><LF>

IMPORTANT: Password is case sensitive.
IMPORTANT: If password is forgotten, Contact LTI for help.

$PS Change Password

This command is used to change password or disable password. Commands that are password protected from change if enabled: $PS,$MM,$MU,$DM,$PD,$SU
IMPORTANT: Password is case sensitive.
Reserved Password: *NO_PASSWORD* is reserved to disable the password function. Entering this password will disable the $PW function. Note: The factory default is password disabled.

Set: $PS,*pw*<CR><LF> Sensor 1st Reply: $OK,PS AGAIN*CRC16<CR><LF>
$PS,*pw*<CR><LF> Sensor 2nd Reply: $OK*CRC16<CR><LF>

where: $ = message identifier

<CR> = carriage return
<LF> = line feed

Example: 1st Input: $PS,NO_PASSWORD<CR><LF>
Reply: $OK,PS AGAIN*7774<CR><LF>
2nd Input: $PW,NO_PASSWORD<CR><LF>
Reply: $OK*0774<CR><LF>

IMPORTANT: Use **$SU** or **$PD** to store new password into non-volatile memory.

$RD Set Trip Distance

S300 and S310 will execute trip output (see $TG) when distance is greater than min value and less than max value. Range measurement units defined by the $MU (Measurement Units) command.

Set: $RD,x,y <CR><LF> Instrument Reply:
Get: $RD<CR><LF> $RD,x,y,z*CRC16*CRC16<CR><LF>

where: $ = message identifier
RD = mnemonic for Trip Distance
x = minimum value range
y = maximum value range
z = measurement Unit
<CR> = carriage return
<LF> = line feed

Example: Input: Get $RD<CR><LF>
Reply: RD,1.000,2.000,F*9C91<CR><LF>
Input: Set $RD,1,2<CR><LF>
Reply: $ RD,1.000,2.000,F*9C91<CR><LF>

$SN Instrument Serial Number

Get: **$SN<CR><LF>**

Instrument Reply: **$SN, DS**nnnnnn*CRC16**<CR><LF>**

where: **$** = message identifier
SN = mnemonic for Serial Number
DS*nnnnnn* = instrument serial number
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: Get $SN<CR><LF>
Reply: $SN,DS003990*9A4F<CR><LF>

$ST Stop Distance Measurement

This command will stop measurements. Exceptions would be trigger input in effect (See $TG).

Direct Action:

$ST<CR><LF>** Instrument Reply: **$OK*CRC16**<CR><LF>**

where: **$** = message identifier
ST = mnemonic for Stop Distance Measurement
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: $ST<CR><LF>
Reply: $OK*0774<CR><LF>

$SU Save User Settings

This command is used to save settings such as measurement mode, target mode, or new password to non-volatile memory. If user settings are changed and this command is not issued, the new settings will be active until the unit is powered down. In this case, the next time the unit is powered ON, the previous settings will be active.

Direct Action: **$SU<CR><LF>** Instrument Reply: **$OK***CRC16**<CR><LF>**

I

where: **$** = message identifier
SU = mnemonic for Save User Settings
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: $SU<CR><LF>
Display Banner Turned off $DB,0
Reply: None: System saved and reboot
Input: $PD<CR><LF>
Display Banner Turned on $DB,1
Reply: TruSense S300 Series,DS-330-1.14
PRF[1000/2800] [CP-WP-U-UL]
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$READY

$TG Remote Trigger (TruSense S300 and S310)

This command defines the functionality of Pin 1 and 6 of the OEM or Pin 2 and 5 of the cased versions of the TruSense S300 and S310. The factory default setting is 5, so the sensor is in the SDI-12 functionality. Note: This command has no effect on the TruSense S330.

IMPORTANT: There is additional current draw if the external trigger input voltage is higher than 5.6 VDC. To minimize power consumption, add a serial resistor (10K to 20K is recommended). Without this resistor, the S300 will draw an additional 60mW at 12VDC. If using 24 VDC, this resistor is required.

IMPORTANT: The sensor will not respond to the stop command ($ST) when trigger is active low.

IMPORTANT: When $TG is set to 1 or 2, trigger input voltage recommendation is **5 vdc**. Sensor trigger activate high is **3 vdc or greater**. Valid trigger duration must be **40ms** or greater.

IMPORTANT: When $TG is set to 3 or 4, maximum sensor current drive is 40mA.

Set: **$TG,***tg***<CR><LF>** Instrument Reply: **$TG,***tg**CRC16**<CR><LF>**

Get: **$TG<CR><LF>** Instrument Reply: **$TG,***tg**CRC16**<CR><LF>**

where:
- **$** = message identifier
- **TG** = mnemonic for Remote Trigger
- *tg* = Manual Start status
  - 0= External port disabled.
  - 1= Trigger input (+5V or 0V) - active high
  - 2= Trigger input (+5V or 0V) - active low
  - 3= Trip output (+5V with 1K serial resister) - active high
  - 4= Trip output (+5V with 1K serial resister) - active low
  - 5= SDI-12 configuration, only available on S310
- *CRC16 = 16-bit CRC
- **<CR>** = carriage return
- **<LF>** = line feed

Example:

Input: Get $TG<CR><LF>
Reply: $TG,0*F1BC<CR><LF>

Input: Set $TG,4<CR><LF>
Reply: $TG,4*32BD<CR><LF>

$UO User Offset

This is used to fine-adjust zero point in sensor setup installation.

Note: The limits of the offset are -32 or +32 units, based on the $MU (Measurement Units) command. Units and resolution are defined by the $MU command.

Set: $UO,***n***<CR><LF> Instrument Reply: **$UO,***n**CRC16**<CR><LF>**
Get: $UO<CR><LF> Instrument Reply: **$UO,***n**CRC16**<CR><LF>**

where:
- **$** = message identifier
- **OU** = mnemonic for User Offset
- **n** = User Offset. Either positive or negative
- *CRC16 = 16-bit CRC
- **<CR>** = carriage return
- **<LF>** = line feed

Example:

Input: Get $UO<CR><LF>
Reply: $UO,-0.315,F*E09C<CR><LF>

Input: Set $UO,-0.315<CR><LF>
Reply: $UO,-0.315,F*E09C<CR><LF>

Note: The TruSense underlying User Offset units are in meters. Minor rounding will occur when using feet.

$VO Turn Laser Pointer On (S310 and S330 Only)

Set: **$VO<CR><LF>** Instrument Reply **$OK***CRC16**<CR><LF>**

where:
- **$** = message identifier
- **VO** = mnemonic for Turn Laser Pointer On

<CR> = carriage return
<LF> = line feed

Example: Input: Set $VO<CR><LF>
Reply: $OK*0774<CR><LF>

Warning: Visible Laser Pointer is not eye safe. If Laser Pointer is on when the $PD or $SU are executed, the laser pointer will be on every time the sensor is powered up.

$VF Turn Laser Pointer Off (S310 and S330 Only)

Set: **$VF<CR><LF>** Instrument Reply: **$OK***CRC16**<CR><LF>**

where:
$ = message identifier
VF = mnemonic for Turn Laser Pointer Off
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: Set $VF<CR><LF>
Reply: $OK*0774<CR><LF>

$WU Warm Up Period

The Warm Up Period is the number of measurements which will be discarded before the first measurement is displayed.

Set: $WU,***n***<CR><LF> Instrument Reply: **$WU,***n**CRC16**<CR><LF>**
Get: $WU<CR><LF> Instrument Reply: **$WU,***n**CRC16**<CR><LF>**

where:
$ = message identifier
WU = mnemonic for Warm Up Period
n = Number of measurements discarded before the first measurement displayed
0 = Warm Up Period is disabled.
non-zero = Warm Up Period is enabled. Valid Range: 1 to 99.
*CRC16 = 16-bit CRC
<CR> = carriage return
<LF> = line feed

Example: Input: Get $WU<CR><LF>
Reply: $WU,8*761D<CR><LF>
Input: Set $WU,10<CR><LF>
Reply: $WU,10*4DB0

10 Reference

Application Examples

These examples are not absolute - sensor setup configuration varies depending on ambient conditions, target integrity, distance, constraints, and user requirements.

Liquid Measurement

To measure the material depth in the tank or vessel (the top of a liquid):

- The sensor must be able to penetrate air-born fog or mist inside the vessel. Choose Last Target for this.
- Set the unit to begin measuring upon power up - enable AutoStart. AutoStart will allow sensor to automatically re-start after a power re-start. See $MA command.
- Each type of liquid surface conditions may react differently, and the user will need to adjust the settings for optimum performance. See $OS command.
- Measuring liquid in an agitated state might achieve more accurate results if a stilling well or a by-pass pipe is used, as shown below.

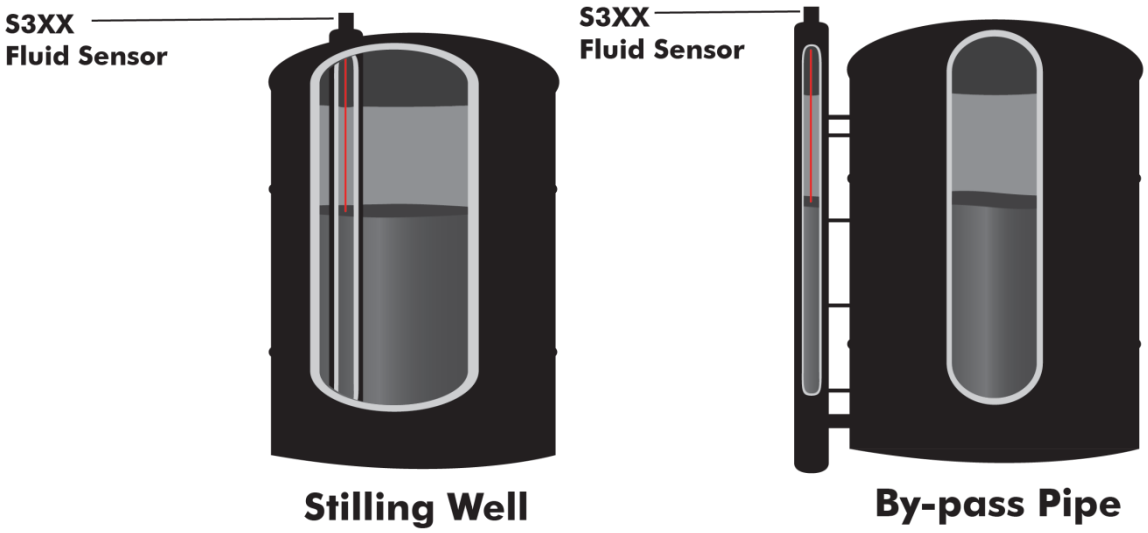


Figure 4: Tank and Vessel Liquid

11 SDI-12 Communication

INTRODUCTION

In addition to a standard serial RS-232 for configuration and reporting interface, the TruSense S300 and S310 liquid laser sensors also provide a standardized SDI-12 serial interface for level measurement reporting and configuration.

This section of the manual provides a detailed description of the LTI-implemented SDI-12 commands of the SDI-12 communications protocol for the S300/S310. For more information on the SDI-12 commands, please refer to SDI-12 – A **S**erial-**D**igital **I**nterface Standard for Microprocessor-Based Sensors, Version 1.3, January 28, 2016, http://www.sdi-12.org/.

The SDI-12 protocol allows sensor specific setup commands (Extended Commands). The TruSense S300 and S310 provides a complete command set to configure the sensor in any liquid level measurement environment.

The TruSense S300 and 310 are configured with the SDI-12 enabled and basic liquid mode settings that will cover most liquid management level installations. The heart of the liquid setup is the $OS serial command and its parameters. For more information see $OS under the RS-232 ASCII commands. All commands for setting up liquid measurements are accessible through the serial RS-232 ASCII commands or the SDI-12 Extended commands. Below is a table of the commands directly relevant to Liquid sensing.

Liquid Setup Commands	Serial Commands	Description	SDI-12 equivalent
Liquid Setup	$OS		
		Filter Mode	aXBn!
		Frequency	aXDn!
		Advanced Filtering	aXEn!
		Running Average	aXFn!
Consecutive Error Reporting	$CE	Error Count	aXGn!
Measurement Mode	$MM	Liquid Mode = 4	aXAn!
Target Mode	$DM	First = 5 Last = 7	aXHn!

Table 3: Liquid Setup Commands

S300 / S310 SDI-12 Configuration

To use the SDI-12 interface of the S300/S310 laser sensors, the sensor's factory default enables the SDI -12 interface (See $TG). Once SDI-12 is enabled, the sensor can be configuring via SDI-12 or RS-232 using the standard serial interface commands. The following outlines the S300/S310 configuration process to enable the SDI-12 communications if disabled through the RS-232 communication:

- If pass word is enabled, enter the password (assumes default password) with "$PW,admin" Note: Factory default is password disabled.
- Enable the SDI-12 interface with the "$TG,5" command.
- Enable error reporting "$NE,0" command.

- Set the desired Measurement Units and optional reported number of digits after the decimal point with the "$MU" command (See $MU command).

The following setup parameters can use either the RS-232 or SDI-12 communication pathway once enabled. RS-232 commands are listed as follows:

- The "$MM" command must always be "$MM,4" for liquid sensing.
- Ensure the Target Mode is valid with the command parameter (See $DM command).
- The sensor Warm-up Period ("$WU") may also need to be adjusted to give a reasonable measurement start time.
- Liquid command is set using the $OS command (See $OS command).
- Consecutive error tracking is set by the $CE command (See $CE command)

IMPORTANT: Save the settings with the "$SU" command (See $SU command). This command must be executed to store changes in non-volatile memory.

Once the Direct Action $SU command is sent, the S300/S310 laser sensor will reset and its SDI-12 interface is now configured for SDI-12 communications. Note that any SDI-12 initiated measurements are also reported on the serial interface as well, using the *RS-232 Measurement Output Messages* (See section 8). See Section **Diagrams - Wiring and Pinouts,** for the wiring diagrams to connect the S300/S310 sensor to an SDI-12 bus.

The SDI-12 configuration can be subsequently further refined using the LTI extended SDI-12 configuration commands "aX_n!" to configure the sensor.

SDI-12 Data Packet Formats

The S300/S310 responds to commands sent to it by an SDI-12 data recorder. Command packets should have the format:
<a><command-data>!
where:

- <a> is the S300/S310's SDI-12 address character (valid values are ASCII „0" to „9", „A" to „Z", „a" to „z", „?")
- <command-data> is a string of zero or more command dependent data characters (values in the range 0x20-0x7E {ASCII „space" to „~"}, excluding 0x21 (ASCII "!"))
- the packet command is terminated by 0x21 (ASCII „!")
  IMPORTANT: ALL SDI-12 COMMANDS ARE UPPER CASE.

Response packets have the format:
<a><response-data>[<CRC>]<CR><LF>
where:

- <a> is the S300/S310's SDI-12 address character
- <response-data> is a string of zero or more command dependent data characters
  - (values in the range 0x20-0x7E {ASCII „space" to „~"})
- <CRC>, optionally available only with measurement responses, but when present, is a string of 3 characters encoding the 16-bit cyclic redundancy check of the response data from the address character through the character preceding the 1st CRC character (1st CRC character is in the range 0x40-0x4F, 2nd and 3rd CRC
  - characters are in the range 0x40-0x7F)
- the packet is terminated by a carriage return followed by a line feed

The formats of the individual command/response packets that the S300/310 supports are described in the following subsections.

S300/S310 SDI-12 Commands Implementation Notes:

- '?' can be used for 'a' in any commands as a wildcard SDI-12 address if only 1 device is on the SDI-12 bus
- '0' is implied and can be left off of commands "aD0!", "aR0!", and "aRC0!"
- "aM0!" can be used in place of "aM!"
- "aMC0!" can be used in place of "aMC!"
- "aC0!" can be used in place of "aC!"
- "aCC0!" can be used in place of "aCC!"
- specified measurements ID:
- „0“ measurement is measurement data defined by $DM(RS-232) or aXHn!(SDI-12)
- „5“ measurement is “temperature” measurement data

12 SDI-12 Commands

LTI S300/S310 Supported SDI-12 Commands Summary.

Command	Response	Description
?!	a<CR><LF> *where*: a = sensor SDI-12 address	Address Query - Query for **any** device on the bus There must be only one device on the SDI-12 bus and it will respond with its SDI-12 address.
a!	a<CR><LF> *where*: a = sensor SDI-12 address	Acknowledge Active - Query for a **specific** device on the bus – there is no response if the specific device is not on the SDI-12 bus.
aI!	annccccccccmmmmmmvvvxxxxxxxxxxxxx<CR><LF> *where*: a = sensor SDI-12 address nn = SDI-12 compatibility version number (n.n) cccccccc = company name mmmmmm = sensor model vvv = sensor FW version number xxxxxxxxxxxxx = sensor serial number	Query Identification - Query for sensor ID info example: "113LASERTECS310 413001442" address = 0 SDI-12 Version 1.3 LASERTEC S310 FW: 1.14-113 S/N: DS001422
aAb!	a<CR><LF> *where*: a = sensor"s new SDI-12 address	Change Address - Change sensor"s SDI-12 address This changes the sensor"s SDI-12 address from address „a" to address „b". Example: aAb!
aM! (aM0!)	atttn<CR><LF> *where*: a = sensor SDI-12 address ttt = the specified time, in seconds, until the sensor will have the data ready n = the number of measurement items Followed by, if „ttt" is non-zero, before „ttt" seconds: a<CR><LF> (i.e. service request – data ready) *where*: a = sensor SDI-12 address	Start Measurement "aXHn! Setting" Use the "aD0!" command to retrieve up to the first 5 measurements of the "aXHn!" measurement data, then the "aD1!" command to retrieve up to the next 5 measurements of the "aXHn!" measurement data, then the "aD2!" command to retrieve up to the next 5 measurements of the "aXHn!" measurement data, then the "aD2!" command etc. until all measurements are retrieved
aM5!	The same as the "aM!" response.	Start Measurement "Temperature" The same as the "aM!" description except it"s for the "Temperature" data.
aM1! – aM4! aM6! – aM9!	a0000<CR><LF> *where*: a = sensor SDI-12 address 0000 = indication that these measurements are not supported	Start Additional Measurement (not supported)
aMC! (aMC0!)	The same as the "aM!" response.	Start Measurement "aXHn!" w/CRC The same as the "aM!" description except it's for the "aXHn!" measurements with CRC.
aMC5!	The same as the "aM!" response.	Start Measurement "Temperature" w/CRC The same as the "aM!" description except it's for the "Temperature" data with CRC.
aMC1! – aMC4! aMC6! – aMC9!	a0000<CR><LF> where: a = sensor SDI-12 address 0000 = indication that these measurements are not supported	Start Additional Measurement w/CRC (not supported)
aC! (aC0!)	atttnn<CR><LF> where: a = sensor SDI-12 address ttt = the specified time, in seconds, until the sensor will have the data ready nn = the number of measurement items	Start Concurrent Measurement "aXHn!" The same as the "aM!" description except it"s for the "aXHn!1" concurrent measurements.
aC5!	The same as the "aC!" response.	Start Concurrent Measurement "Temperature" The same as the "aM!" description except it"s for the "Temperature" concurrent measurements.

aC1! – aC4! aC6! – aC9!	a00000<CR><LF> where: a = sensor SDI-12 address 00000 = indication that these measurements are not supported	Start Additional Concurrent Measurement (not supported)
aCC! (aCC0!)	The same as the "aC!" response.	Start Concurrent Measurement "aXHn!" w/CRC The same as the "aM!" description except it's for the "aXHn!" measurements.
aCC5!	The same as the "aC!" response.	Start Concurrent Measurement "Temperature" w/CRC The same as the "aM!" description except it's for the "Temperature" measurements.
aCC1! – aCC4! aCC6! – aCC9!	a00000<CR><LF> where: a = sensor SDI-12 address 00000 = indication that these measurements are not supported	Start Additional Concurrent Measurement w/CRC (not supported)
aR0! (aR!)	a<value><CR><LF> where: a = sensor SDI-12 address <value> = pn.d where: p = the polarity sign („+" or „–„) n = numeric digits before the decimal point „." = the decimal point d = the numeric digits after the decimal point	Start Continuous Measurement "aXHn!" The maximum number of digits for a data value is 7. The minimum number of digits for a data value is 1. The maximum number of characters in a data value is 9 (polarity sign + 7 digits + decimal point).
aR5!	a+nn.n<CR><LF> where: a = sensor SDI-12 address + = sign of the on-board temperature value nn.n = the on-board temperature (°C)	Start Continuous Measurement "Temperature" The same as the "aR0!" description except it's for the "Temperature" data.
aR1! – aR4! aR6! – aR9!	a<CR><LF> where: a = sensor SDI-12 address and nothing else indicating that these measurements are not supported	Start Additional Continuous Measurement (not supported)
aRC0! (aRC!)	a<values><CRC><CR><LF> where: a = sensor SDI-12 address <values> = pn.d where: p = the polarity sign („+" or „–„) and measurement separator character n = numeric digits before the decimal point „." = the decimal point d = the numeric digits after the decimal point <CRC> = the 3-character encoded 16-bit CRC of the response	Retrieve Continuous Measurement "First #1" w/CRC The maximum number of digits for a data value is 7. The minimum number of digits for a data value is 1. The maximum number of characters in a data value is 9 (polarity sign + 7 digits + decimal point).
aRC5!	a+nn.n<CRC><CR><LF> where: a = sensor SDI-12 address + = sign of the on-board temperature value nn.n = the on-board temperature (°C) <CRC> = the 3-character encoded 16-bit CRC of the response	Retrieve Continuous Measurement "Temperature" w/CRC The same as the "aRC0!" description except it's for the "Temperature" data.
aRC1! – aRC4! aRC6! – aRC9!	a<CRC><CR><LF> *where*: a = sensor SDI-12 address and nothing else indicating that these measurements are not supported <CRC> = the 3-character encoded 16-bit CRC of the response	Retrieve Additional Continuous Measurement w/CRC (not supported)

aD0! (aD!)	a<values><CR><LF> -or- a<values><CRC><CR><LF> *where*: a = sensor SDI-12 address <values> = pn.d where: p = the polarity sign („+" or „–„) and measurement separator character n = numeric digits before the decimal point „." = the decimal point d = the numeric digits after the decimal point <CRC> = the 3 character encoded 16-bit CRC of the response, appended if the data was requested with the "aMCn!" or "aCCn!" commands	Send Data – 1st Buffer of Measurement(s) or vendor-specific data from the "aV!" command The maximum number of digits for a data value is 7. The minimum number of digits for a data value is 1. The maximum number of characters in a data value is 9 (polarity sign + 7 digits + decimal point).
aD1! – aD6	The same as the "aD0!" response.	Send Data – Additional Buffers of Measurements (for up to 32 measurements) The same as the "aD0!" description.
aD7! – aD9	a<CR><LF> -or- a<CRC><CR><LF> *where*: a = sensor SDI-12 address and nothing else indicating that these measurements are not supported <CRC> = the 3 character encoded 16-bit CRC of the response, appended if the data was requested with the "aMCn!" or "aCCn!" commands	Send Data – Additional Buffers (not supported)
aV!	atttn<CR><LF> *where*: a = sensor SDI-12 address ttt = the specified time, in seconds, until the sensor will have the data ready n = the number of data items	Start Verification - Query for vendor-specific data example: "30006" *where*: 3 = sensor SDI-12 address 000 = ready immediately (0 seconds) 6 items Use the "aD0!" command to retrieve the vendor data example: "8+5+100+22+2+2+4" *where*: 8 = sensor SDI-12 address 5 = number of measurements to take 100 = 10.0 seconds between measurements 22 = "aXV22!" (i.e. "$WU,22") 2 = "$LS,2" (not applicable for Liquid) 2 = "$OP,8" (not applicable for Liquid) 4 = "$MM,4" (Always 4 for Liquid)

LTI S300/S310 Supported SDI-12 Extended Commands.

Command	Response	Description
aXAn!	an<CR><LF> *where*: a = sensor SDI-12 address n = Measurement Mode	In Liquid measurement mode must be always set to 4 Same as serial command $MM,4
aXBn!	an<CR><LF> *where*: a = sensor SDI-12 address n = first parameter of the $OS command	1= lowpass filter 2= median filter See serial command $OS for details
aXCn!	an<CR><LF> *where*: a = sensor SDI-12 address n = auto-start enabled (1), disabled (0)	Enable/disable auto-start n = 0 disables auto-start n = non-zero enables auto-start See serial command $MA
aXDn!	an<CR><LF> *where*: a = sensor SDI-12 address n = second parameter of the $OS command	Controls measurement output per second. Valid values are 1 to 14 See serial command $OS

aXEn!	an<CR><LF> *where*: a = sensor SDI-12 address n = third parameter of the $OS command	IMPORTANT: This must be set to zero. See serial command $OS
aXFn!	an<CR><LF> *where*: a = sensor SDI-12 address n = fourth parameter of the $OS command	Set running average 0= off 2 – 30 = on See serial command $OS
aXGn!	an<CR><LF> *where*: a = sensor SDI-12 address n = set number of consecutive errors	Set number of consecutive errors 0= off 2 – 250 = on See serial command $CE
aXHn!	an<CR><LF> *where*: a = sensor SDI-12 address n = set targeting mode	Set targeting mode 5 = first 6 = strongest 7 = last See serial command $DM
aXMn!	an<CR><LF> *where*: a = sensor SDI-12 address n = number of measurements to make	Set/Get number of measurements to make n = 1 to 32
aXP!	ann<CR><LF> *where*: a = sensor SDI-12 address nn = period between measurements (1/10th secs)	Get measurement update period (currently, read-only) n = tenths of seconds
aXR!	aRESET<CR><LF> *where*: a = sensor SDI-12 address RESET = sensor reset confirmation	Reset sensor
aXS!	aSAVE<CR><LF> *where*: a = sensor SDI-12 address SAVE = sensor save settings confirmation	Save current configuration settings and reset sensor
aXVn!	aV0<CR><LF> *where*: a = sensor SDI-12 address V0 = ???	Turn the alignment laser pointer on/off (S210) Note: No programmatic indication of the laser pointer on/off status is available – only visual observation
aXWn!	an<CR><LF> *where*: a = sensor SDI-12 address n = number of discarded initial measurements	Set warm-up period – i.e. discarded initial measurements count n = 1 to 99 (cannot set to 0 to disable it, use "$WU,0" serial command)

13 SDI-12 Commands Detailed descriptions and Examples

This subsection provides detailed descriptions of the SDI-12 command support for the TruSense S300/S310 laser sensors. Examples identify the command sent to the sensor is shown in **BLUE**, and the response is shown in **GREEN**.

"?!" Address Query

This command queries for **any** devices on the SDI-12 bus. There should only be one device on the SDI-12 bus when this command is issued as all devices will respond with their address, resulting in a corrupted received response if more than one device is responding.

Command: **?!** Response: **a<CR><LF>**

where: **?** = wildcard SDI-12 address
! = SDI-12 command termination
character a = responding sensor's SDI-12 address

Example: **?!8<CR><LF>** The responding sensor's SDI-12 address is „8".

"a!" Acknowledge Active

This command queries for a **specific** device on the SDI-12 bus by its address. If no device is on the SDI-12 bus at the specified address, there will be no response.

Command: **a!** Response: **a<CR><LF>**

where: a = specified sensor's SDI-12 address
! = SDI-12 command termination character

Example: **8!8<CR><LF>** The specified sensor responded.

"aI!" Send Identification

This command queries the S300/S310 for its SDI-12 compatibility level, company name, model number, firmware version, and serial number.

Command:

aI! Response: **annccccmmmvvvxxxx<CR><LF>**

where: **a** = specified sensor's SDI-12 address
I = Send Identification SDI-12 command
! = SDI-12 command termination character
nn = SDI-12 compatibility version number (n.n)
cccc = company name
mmm = sensor model
vvv = sensor FW version number
xxxx = sensor serial number

Example: **8I!813LASERTECS300413000403<CR><LF>**. where: sensor's SDI-12 address = „8"

SDI-12 version = "1.3"
company name = "LASERTEC"
sensor model = "S300"
Firmware version = "1.14-113"
serial number = "DS000403"

"aAb!" Change Address

This command is used to change the SDI-12 for the S300/S310 sensor. The S300/S310 sensor will reset after its SDI-12 address is changed.

Command:

aAb! Response: **b<CR><LF>**

where:
- **a** = specified sensor's current SDI-12 address
- **A** = Change Address SDI-12 command
- b = sensor's new SDI-12 address („0" to „9", „A" to „Z", „a" to
- **!** = SDI-12 command termination character

Example:

8A5!5<CR><LF> The sensor's SDI-12 address changed from „8" to „5".

"aM!" Start Measurement defined by Target Mode "aXHn!" or Serial Command $DM

This command is used to request measurement(s). The "aD0!" command will then be used to retrieve the data when it's ready.

Command:

aM! Response: **atttn<CR><LF>**

where:
- a = specified sensor's current SDI-12 address
- **M** = Start Measurement for "First #1" measurement data SDI-12
- **!** = SDI-12 command termination character
- ttt = the specified time, in seconds, until the sensor will have data
- n = the number of measurements being accumulated

Example: **8M!80025<CR><LF>** Sensor 8 will have 5 measurements in 2 seconds.

followed by: (in approximately 2 seconds)

8<CR><LF> Service Request – the measurements are ready.

"aM5!" Start Measurement for "Temperature"

This command is used to request measurement(s) for the "Temperature" data. The "aD0!" command will then be used to retrieve the data when it's ready.

Command:

aM5! Response: **atttn<CR><LF>**

where:
- a = specified sensor's current SDI-12 address
- **M5** = Start Measurement for "Temperature" measurement data command
- **!** = SDI-12 command termination character
- ttt = the specified time, in seconds, until the sensor will have data ready
- n = the number of measurements being accumulated

Example: **8M5!80015<CR><LF>** The sensor will have 5 "Temperature" data in 1 second. followed by: (in approximately 1 second)

8<CR><LF> Service Request – the measurements are ready.

"aMCn!" Start Specified Measurement with CRC

These commands are used to request specified measurement(s) defined by "aXHn!" or Serial Command $DM and temperature data and include the CRC when it's retrieved. The "aD0!" command will then be used to retrieve the data with the included CRC when it's ready. These commands are the same as the "aM!" or "aM0! and "aM5!" commands except that when the measurement data is retrieved, it will include a CRC.

Command:

aMCn! Response: **atttnn<CR><LF>**

where:
- a = specified sensor's current SDI-12 address
- **MCn** = Start Measurement for specified measurement data with CRC

command (n = „0“ to „5“)
! = SDI-12 command termination character
ttt = the specified time, in seconds, until the sensor will have data
ready n = the number of measurements being accumulated

Example: **8MC!800205<CR><LF>** The sensor will have 5 “First #1” measurements in 2 seconds. followed by: (in approximately 2 seconds)

8<CR><LF> Service Request – the measurements are ready with CRC.

“aC!” Start Concurrent Measurement ; defined by Target Mode “aXHn!” or Serial Command $DM

This command is used to request concurrent measurement(s) defined by “aXHn!” or Serial Command $DM. The “aD0!” command will then be used to retrieve the data when it’s ready.

Command:

aC! Response: **atttnn<CR><LF>**
where: a = specified sensor’s current SDI-12 address
C = Start Concurrent Measurement for measurement data SDI-12 command
! = SDI-12 command termination character
ttt = the specified time, in seconds, until the sensor will have data
ready nn = the number of measurements being accumulated

Example: **8C!800205<CR><LF>** The sensor will have 5 measurements in 2 seconds.

“aC5!” Start Concurrent Measurement for “Temperature”

This command is used to request concurrent measurement(s) for the “Temperature” data. The “aD0!” command will then be used to retrieve the data when it’s ready.

Command:

aC5! Response: **atttnn<CR><LF>**
where: a = specified sensor’s current SDI-12 address
C5 = Start Concurrent Measurement for “Temperature” SDI-12 command
! = SDI-12 command termination character
ttt = the specified time, in seconds, until the sensor will have data
ready nn = the number of measurements being accumulated

Example: **8C4!800105<CR><LF>** The sensor will have 5 “Temperature” data in 1 second.

aCCn!” Start Specified Concurrent Measurement with CRC

These commands are used to request specified concurrent measurement(s) defined by “aXHn!” or Serial Command $DM and temperature data and include the CRC when it’s retrieved. The “aD0!” command will then be used to retrieve the data with the included CRC when it’s ready. These commands are the same as the “aC!” and “aC5!” commands except that when the measurement data is retrieved, it will include a CRC.

Command:

aCCn! Response: **atttnn<CR><LF>**
where: a = specified sensor’s current SDI-12 address
CCn = Start Concurrent Measurement for specified measurement data with SDI-12 command (n = „0“to„5“)
! = SDI-12 command termination character
ttt = the specified time, in seconds, until the sensor will have data
ready nn = the number of measurements being accumulated

Example: **8CC!800205<CR><LF>** The sensor will have 5 measurements in 2 seconds.

"aR0!" Start Continuous Level Measurement

This command is used to request a continuous measurement defined by "aXHn!" or Serial Command $DM. **IMPORTANT:** The sensor must be in Auto-start continuous measurement mode (See aXCn! or serial command $MA).

Command:

aR0! Response: **a<value><CR><LF>**
where: a = specified sensor's current SDI-12 address
R0 = Start Continuous Measurement for "First #1" measurement data command
! = SDI-12 command termination character
<value> = pn.d
where:
p = the polarity sign („+" or „–")
n = the numeric digits before the decimal point
„." = the decimal point
d = the numeric digits after the decimal point

Example: **8R0!8+14.029<CR><LF>** The measurement value is "+14.029".

"aR5!" Start Continuous Measurement for "Temperature"

This command is used to request a continuous "Temperature" data. **IMPORTANT:** The sensor must be in Auto-start continuous measurement mode (See aXCn! or serial command $MA).

Command:

aR5! Response: **a<value><CR><LF>**
where: a = specified sensor's current SDI-12 address
R5 = Start Continuous Measurement for "Temperature" data SDI-12
! = SDI-12 command termination character
<value> = pn.d
where:
p = the polarity sign („+" or „–")
n = the numeric digits before the decimal point
„." = the decimal point
d = the numeric digits after the decimal point

Example: **8R5!8+37.3<CR><LF>** The temperature value is "+37.3 °C".

"aRCn!" Start Specified Continuous Measurement with CRC

These commands are used to request specified continuous measurements for the defined by "aXHn!" or Serial Command $DM and temperature data and include the CRC.

IMPORTANT: The sensor must be in Auto-start continuous measurement mode (See aXCn! or serial command $MA).

Command:

aRCn! Response: **a<value><CRC><CR><LF>**
where: a = specified sensor's current SDI-12 address
RCn = Start Continuous Measurement for specified measurement

CRC SDI-12 command (n = „0“ to„5“)
! = SDI-12 command termination character
<value> = pn.d
where:
p = the polarity sign („+“ or „–“)
n = the numeric digits before the decimal point
„.“ = the decimal point
d = the numeric digits after the decimal point
<CRC> = the 3-character encoded 16-bit CRC of the response

Example: **8RC4!8+14.017CQq<CR><LF>** The “Last” measurement value is “+14.017” with “CQq” the encoded CRC.

“aD0!” Send Data

This command is used to request the first measurement buffer data after measurement(s) are completed after an “aM!”, “aMCn!”, “aC!”, “aCCn!”, or “aV!” command. The amount of measurement data returned depends on the number of measurements taken (See “aXMn). “aM!” and “aMCn!” commands can report up to 5 measurements. “aC!” and “aCCn!” commands can report up to 10 measurements. The “aV!” command reports 6 items.

Command:

aD0!
Response: **a<values><CR><LF>**
–or–
Response: **a<values><CRC><CR><LF>**

where: a = specified sensor“s current SDI-12 address
D0 = Send Data SDI-12 command for first measurement buffer
! = SDI-12 command termination character
<values> = pn.d
where:
p = the polarity sign („+“ or „–„) and measurement character
n = the numeric digits before the decimal point
„.“ = the decimal point
d = the numeric digits after the decimal point
<CRC> = the 3-character encoded 16-bit CRC of the response

Example: **8D0!8+14.012+14.022+0.125+14.017+14.010<CR><LF>**
The measurement values are “+14.012”, “+14.022”, “+0.125”, .“+14.017”, “+14.010”.

Example: **8D0!+14.023+14.016+14.021+14.025Cbp<CR><LF>**
The measurement values are “+14.023”, “+14.016”, “+14.021”, “+14.025” and the encoded CRC is “Cbp”.

Example: **8D0! 8+5+0+30+0+2+4 <CR><LF>** The “aV!” verification values are:
8 = sensor SDI-12 address
5 = number of measurements to take
0 = Not used in Liquid Mode
30 = "aXW10!” (i.e. "$WU,30")
0 =Not used in Liquid mode
2 =Not used in Liquid Mode
4 = “aXA4!” (i.e. “$MM,4”)

"aD1!" to "aD9!" Send Additional Data

These commands are used to request the additional measurement buffer data after measurement(s) are completed after an "aM!", "aMCn!", "aC!", or "aCCn!" command. The amount of measurement data returned depends on the number of measurements taken (See "aXMn). "aM!" and "aMCn!" commands can report up to 5 measurements per buffer. "aC!" and "aCCn!" commands can report up to 10 measurements per buffer. A data request for a buffer that is empty will return nothing but its SDI-12 address (and the CRC if the previous measurement request specified a CRC).

The S300/S310 sensor can take up to 32 measurements per measurement request. The measurements data is placed into the D0 buffer first, and then when it is full, additional measurements data is placed into the D1 buffer until it is full, followed by the D2 buffer, etc. until all measurements (up to 32) have been stored in the measurement's buffers.

Command:

aDn! Response: **a<values><CR><LF>**
–or–
Response: **a<values><CRC><CR><LF>**

where: a = specified sensor"s current SDI-12 address
Dn = Send Data SDI-12 command for the specified measurement buffer (n = „1" to „9")
! = SDI-12 command termination character
<values> = pn.d (or nothing if the buffer is empty)
where:
p = the polarity sign („+" or „–„) and measurement separator character
n = the numeric digits before the decimal point
„." = the decimal point
d = the numeric digits after the decimal point
<CRC> = the 3-character encoded 16-bit CRC of the response

Example: **8D0!8+14.012+14.022+0.125+14.017+14.010<CR><LF>**
The measurement values are "+14.012", "+14.022", "+0.125", "+14.017", "+14.010".

Example: **8D0!+14.023+16+14.021+14.025Cbp<CR><LF>**
The measurement values are "+14.023", "+14.016", "+14.021", "+14.025" and the encoded CRC "Cbp".

Example: **8D4!8<CR><LF>** The buffer is empty.

Example: **8D4!8MHA<CR><LF>** The buffer is empty, and the encoded CRC is "MHA".

"aV!" Start Verification

This command is used to request various S300/S310 configuration settings. The "aD0!" command will then be used to retrieve the data when it's ready.

Command:

aV! Response: **atttn<CR><LF>**
where: a = specified sensor's current SDI-12 address
V = Start Verification SDI-12 command
! = SDI-12 command termination character
ttt = the specified time, in seconds, until the sensor will have data
n = the number of items being accumulated

Example: **8M!80006<CR><LF>** The sensor ID 8 has 6 items ready immediately. See aV! for example configuration settings data.

The six configuration settings items returned are:

1. the current measurement iteration count ("aXMn!" or „n" in "$GO,n,m")

2. the current measurement update period („m“ in "$GO,n,m" – in tenths of seconds)
3. the current warm-up period ("aXWn!" or "$WU")
4. the current scan mode ("$LS") Note**:** Not used in Liquid mode.
5. the current P.P.M. value divided by 4 ("$OP") Note: Not used in Liquid mode.
6. the current measurement mode ("$MM") Note: Must be 4 in Liquid mode.

"aXAn!" Set Measurement Mode

This LTI-proprietary SDI-12 extended command configures measurement mode. This corresponds to the "$MM,n" serial command.

IMPORTANT: For Liquid measurement the serial command must be set to "$WU,4".

Command:

aXAn!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XA	= Set Measurement Mode extended SDI-12 command
	n	= the number of initial discarded measurement laser firings (1
	!	= SDI-12 command termination character

Example: **8XA4!8MM4<CR><LF>** The sensor is set to measurement mode 4 (Liquid Mode)

Note: Sending "aXA!" (without the „n“ value) can be used to query for the current measurement mode setting.

"aXBn!" Set Liquid Filter Mode

This LTI-proprietary SDI-12 extended command configures the first parameter of the Liquid Setting. This corresponds to the first parameter of the "$OS,f,z,0,y" serial command.

Command:

aXBf!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XB	= Set Liquid Filter extended SDI-12 command
	f	= Lowpass filter = 1 and Median filter = 2
	!	= SDI-12 command termination character

Example: **8XB2!8B2<CR><LF>** The sensor is set to liquid filter mode 2 (Liquid filter median)

Note: Sending "aXB!" (without the „n“ value) can be used to query for the current measurement mode setting.

"aXCn!" Enable/Disable Auto-Start Mode

This LTI-proprietary SDI-12 extended command enables or disables auto-starting of continuous measurements by the S300/S310 sensor. To obtain measurement data with the "aRn" continuous measurements commands, the S300/S310 sensor must have its auto-start mode enabled. The S300/S310 sensor will reset after its auto-start mode is changed. This corresponds to the "$MA,n" serial command.

Command:

aXCn!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XC	= Enable/Disable Auto-Start Mode extended SDI-12 command
	n	= enable/disable value („0“ = disable, non-0 = enable – responds
	!	= SDI-12 command termination character

Example: **8XC1!81<CR><LF>** The sensor's auto-start mode has been enabled.

Note: Do **not** send "aXC!" (without the „n" value) in an attempt to query for the current Auto-Start setting. This will actually enable the Auto-Start mode!

"aXDn!" Set Liquid Output

This LTI-proprietary SDI-12 extended command configures the second parameter of the Liquid Setting. This corresponds to the second parameter of the "$OS,f,z,0,y" serial command.

Command:

aXDz!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XD	= Set Liquid measurement output SDI-12 command
	z	= Output 1 – 14 per second
	!	= SDI-12 command termination character

Example: **8XD2!8D2<CR><LF>** The sensor is set to 2 measurements per second.

Note: Sending "aXD!" (without the „n" value) can be used to query for the current measurement mode setting.

"aXEn!" Set Advanced Filter

IMPORTANT: Must always be set to zero for proper operation.

This LTI-proprietary SDI-12 extended command configures the third parameter of the Liquid Setting. This corresponds to the third parameter of the "$OS,f,z,0,y" serial command.

Command:

aXE0!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XE	= Set Liquid measurement output SDI-12 command
	0	= always set to zero = off
	!	= SDI-12 command termination character

Example: **8XE0!8E0<CR><LF>** The sensor is set to default value of zero.

Note: Sending "aXE!" (without the „n" value) can be used to query for the current liquid advanced filter setting.

"aXFn!" Set Running Average

This LTI-proprietary SDI-12 extended command configures the fourth parameter of the Liquid Setting. This corresponds to the fourth parameter of the "$OS,f,z,0,y" serial command.

Command:

aXFn!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XF	= Set Liquid measurement output SDI-12 command
	y	= Running Average 0=off 2-30 = on
	!	= SDI-12 command termination character

Example: **8XF0!8F0<CR><LF>** The sensor is set to default value of zero.

Note: Sending "aXF!" (without the „n" value) can be used to query for the current running average setting.

"aXGn!" Number of Consecutive Errors

This LTI-proprietary SDI-12 extended command configures the number of consecutive errors before reporting an error. This corresponds to the $CE serial command.

Command:

aXGn!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XG	= Set Consecutive Errors SDI-12 command
	n	= Consecutive errors 0=off 2-250 = on
	!	= SDI-12 command termination character

Example: **8XG5!8CE5<CR><LF>** The sensor is set to default 5 consecutive error before reporting an actual error.

Note: Sending "aXG!" (without the „n" value) can be used to query for the current consecutive error setting.

"aXHn!" Set Target Mode

This LTI-proprietary SDI-12 extended command configures Targeting mode. This corresponds to the $DM serial command.

Command:

aXHn!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XH	= Set Target Mode
	n	= 5=first 6=strongest 7=last
	!	= SDI-12 command termination character

Example: **8XH5!8DN5<CR><LF>** The sensor is set to default 5, first target mode.

Note: Sending "aXH!" (without the „n" value) can be used to query for the current target mode.

"aXMn!" Set Number of Measurements to Make

This LTI-proprietary SDI-12 extended command configures the number of measurements that should be made by the S300/S310 sensor when a start measurement request is issued. This allows multiple measurements to be reported after a measurement request. This corresponds to the „n" in the "$GO,n,m" serial command.

Command:

aXMn!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XM	= Set Number of Measurements to Make extended SDI-12
	n	= the number of measurements to make (1 to 32)
	!	= SDI-12 command termination character

Example: **8XM12!812<CR><LF>** The sensor is set to make 12 measurements.

Note: Sending "aXM!" (without the „n" value) can be used to query for the current number of measurements to make setting.

"aXP!" Get Measurement Update Period

This LTI-proprietary SDI-12 extended command reports the period between measurements setting that is used by the S300/S310 sensor configured for multiple measurements per measurement request when a start measurement request is issued. This currently is only a read-only value. This corresponds to the „m" (in tenths of seconds, however) in the "$GO,n,m" serial command.

Command:

aXP!		Response: **an<CR><LF>**
where:	a	= specified sensor's current SDI-12 address
	XP	= Get Measurement Update Period extended SDI-12 command

n	= the period between multiple measurements (in tenths of a second)
!	= SDI-12 command termination character

Example: **8XP15!815<CR><LF>** The sensor is set to make measurements every 1.5 seconds.

"aXR!" Reset Instrument

This LTI-proprietary extended command resets the S300/S310 sensor. This corresponds to the "$PD" serial command.

Command:

aXR! Response: **aRESET<CR><LF>**

where:	a	= specified sensor's SDI-12 address
	XR	= Reset Instrument extended SDI-12 command
	!	= SDI-12 command termination character
	RESET	= confirmation that the reset is about to occur

Example: **8XR!8RESET<CR><LF>** The sensor has reset.

"aXS!" Save Current Settings

This LTI-proprietary SDI-12 extended command saves the current configuration settings in non-volatile memory in the S300/S310 sensor. The sensor is reset after the settings are saved. This corresponds to the "$SU" serial command.

Command:

aXS! Response: **aSAVE<CR><LF>**

where:	a	= specified sensor's SDI-12 address
	XS	= Save Settings extended SDI-12 command
	!	= SDI-12 command termination character
	SAVE	= confirmation that the configuration settings are about to be saved

Example: **8XS!8SAVE<CR><LF>** The sensor has saved its settings and reboots.

"aXVn!" Turn Alignment Laser Pointer On/Off

This LTI-proprietary SDI-12 extended command turns the alignment laser pointer on the S310 sensor on or off. This corresponds to the "$VO" and "$VF" serial commands. This command is for the S310 laser sensor only. Note: The S300 does not have an alignment laser pointer.

Command:

aXVn! Response: **aV0<CR><LF>**

where:	a	= specified sensor's current SDI-12 address
	XV	= Alignment Turn Laser Pointer On/Off extended SDI-12
	n	= 1=on 0=off
	!	= SDI-12 command termination character
	V0	= confirmation that the command was accepted

Example: **8XV1!8V0<CR><LF>** The S310 sensor turned on the laser pointer.

Note: Send "aXV!" (without the „n" value) will query for the current alignment laser pointer setting status. If the pointer is off the response will be 0 and if the pointer is on the response will be 2.

"aXWn!" Set Warm-Up Period

This LTI-proprietary SDI-12 extended command configures number of initial measurement laser firings which will be discarded before the first measurement is available. This corresponds to the "$WU,n" serial

command.

Command:

aXWn! Response: **an<CR><LF>**

where: a = specified sensor's current SDI-12 address
XW = Set Warm-Up Period extended SDI-12 command
n = the number of initial discarded measurement laser firings (1
! = SDI-12 command termination character

Example: **8XW10!810<CR><LF>** The sensor is set to a warm-up period of 10 discarded measurement laser firings.

Note: Sending "aXW!" (without the „n" value) can be used to query for the current warm-up period setting.

14 Specifications

Performance:	Min. Range:	46 cm (1.4 ft.)
	Max. Range:	50 meters; (164 ft.)
	Accuracy:	±10 mm (.39 in.)
	Data Output Rate:	Option 1: <1 up to 14 Hz depending on target.
	Target Modes:	First, Strongest, or Last
Optical & Electrical:	Wavelength:	905 nm (near IR)
	Beam Divergence:	3 mrad (equal to 1 foot beam diameter at 328 feet or 30 cm at 100 meters)
	I/O:	S-300 = RS232, SDI-12, TRIG, no alignment laser S-310 = RS232 , SDI-12, TRIG with alignment laser S-330 = 4-20mA, RS232 with alignment laser
	Input Power:	12-24 VDC (12VDC recommended)
	Power Draw:	Measuring = 1.8 Watts, standby = .48 Watts
Physical:	Dimensions (LxWxH):	104.4 x 81.7 x 41.6 mm (4.11 x 3.22 x 1.64 in)
	Weight:	Standard = 138.6g (4.8 oz.) OEM = 76g(2.7 oz.)
	Housing & Frame Material:	Glass-filled polycarbonate
Environmental:	Eye Safety:	Class I, 7mm (FDA CFR21)
		Class 1m (IEC 60825-1:2001)
	Shock Vibration:	MIL-STD-810
	Dust/Moisture:	IP65
	Operating Temperature:	-28º to 60º C (-20º to 140º F)

Table 4: Specifications

15 Error Codes RS-232

There are three types of errors:
User, Environmental, and Critical. User and Environmental errors can usually be corrected in the field. For Critical errors, if reoccurring, contact LTI for evaluation and/or repair.
IMPORTANT: 5 consecutive critical errors will cause the sensor to reboot.

Number	Error Name	Error Type	Description
1	NO TARGET	User Error	No Target found. Receiver did not receive Transmit Laser pulse
2	DATA INSUFFICIENT	User Error	Receiver did not receive enough good laser pulses to calculate distance. Increase second parameter of the $OS command.
3	DATA UNSTABLE	User Error	Too much variation in distance. Increase second parameter on the $OS command.
7	JAM DETECTED	User Error	Light interference. This is typically caused by sun light entering in the receiver optic.
9	RANGE ERROR	User Error	Most commonly due to dirty optics on Transmit and/or Receiver lens, Fog and or Steam.
20	UNDEFINED COMMAND	User Error	RS-232 command that was sent to sensor not valid.
22	SYNTAX ERROR	User Error	RS-232 Incorrect parameter format for command sent to sensor.
23	OUT OF RANGE	User Error	Range out of bounds. To close or too far.
24	INCORRECT PASSWORD	User Error	Check Password that was sent to sensor. Note: Password is case sensitive.
25	PASSWORD REQUIRED	User Error	Command sent to sensor is password protected and Password is enabled.
34	NOT ALLOW COMMAND	User Error	Command not allowed in current sensor configuration.
35	INVALID PARAMETER	User Error	RS-232 Incorrect parameter sent to sensor.
36	FAILED EXECUTION	User Error	Failed to execute RS-232 command sent to sensor.
54	LOW BATTERY	User Error	Voltage has dropped below minimum sensor requirements to operate.
52	TOO COLD	Environmental Error	Temperature is below safe operation. Once warmed up above minimum temperature, sensor will resume operation.
53	TOO HOT	Environmental Error	Temperature is above safe operation. Once cooled down below maximum temperature, sensor will resume operation.
38	INVALID HARDWARE CONFIGURATION	Critical Error	Possible Hardware failure.
56	SPAN ERROR	Critical Error	Low level distance calculation error.
58	ADC/DAC ERROR	Critical Error	ADC to DAC converting error.
59	RX CAL ERROR	Critical Error	Receiver calibration error. Possible defective receiver.
60	STACK OVERFLOW	Critical Error	Code space error.
62	APD FAILED	Critical Error	Defective Receiver.
63	FLASH MEMORY:	Critical Error	Calibration memory defective.

	CAL		
64	FLASH MEMORY: SYS1	Critical Error	System memory defective
65	FLASH MEMORY: SYS2	Critical Error	System memory defective
66	FLASH MEMORY: USER	Critical Error	User memory defective.
67	FLASH MEMORY: CODE	Critical Error	Memory address defective.
68	HV TX FAILED	Critical Error	Transmitter hi voltage circuit defective.
69	TX REFERENCE TIMING	Critical Error	Measurement timing circuit failure.
70	HV RX FAILED	Critical Error	Receiver hi voltage circuit defective.

Table 5: Error Codes

16 Troubleshooting

Problem	Remedy
Sensor not powering on	• Check Power and ground cable connections • Check for broken connector pins (cased version sensor) • Check power supply output voltage
Sensor not communicating RS-232	• Check for broken connector pins (cased version sensor) • Verify Com RX is connected to sensor Tx and Sensor Rx is connected to Com Tx • Check the correct com port is available • Verify the configuration and baud rate of terminal program is the same as sensor setup • Check Output Setup Port
Sensor not communicating in SDI-12 (S300 and S310)	• Check for broken connector pins (cased version sensor) • Verify senor is wired correctly in the SDI-12 bus • Check for broken wires • Using RS-232 communication check $TG = 5 • Verify sensor ID assignment
Sensor not communicating 4-20mA (S330)	• Check for broken connector pins (cased version sensor) • Check for broken wires • Verify current loop power source • Verify sensor source and return are wired correctly
Inaccurate measurement	• Verify mounting aliment 90 degrees to liquid surface • Turbulent liquid surface increase fourth parameter of the $OS command. • Look for obstructions in laser path between laser and liquid surface • Dense steam of fog present • Verify measurement units are correct for your applications(Meter or Feet) • Check User's Offset $UO for correct offset
Periodic Error Code E0-1	• Turbulent liquid surface increase $CE • Verify mounting aliment 90 degrees to liquid surface
Sensor measurement not reading	• Make sure lens is clean from dust and excessive condensation • Check for condensation between diffuser lens and sensor lens

Table 6: Troubleshooting

17 Care and Maintenance

Operating Temperature

The S300 is rated for a temperature range of -20° F to 140° F (-28° C to 60° C). Do not operate the instrument in temperatures outside of that range.

Moisture and Dust Protection

The S3xx sensor is rated IP65. According to the international standard EN 60529, this is defined as "protected against dust that might harm the equipment" and "protection against water spray from all directions". Dust should not be allowed to accumulate on the lens beyond a certain level that might interfere with the laser beam's ability effectively range to a target and return back to the receiver (see Cleaning below).

The sensor should not be immersed in water (or other liquids). If placed into particularly challenging environments, an enclosure or cover should be considered.

Cleaning

Exterior Dirt: Use a small blower brush to blow off or brush away loose dust or debris.

Dirty Lenses: The best way to clean a lens is to use a piece of lint free lens cleaning tissue and a small amount of lens cleaning solution. Do not use anything containing abrasives or solvents.

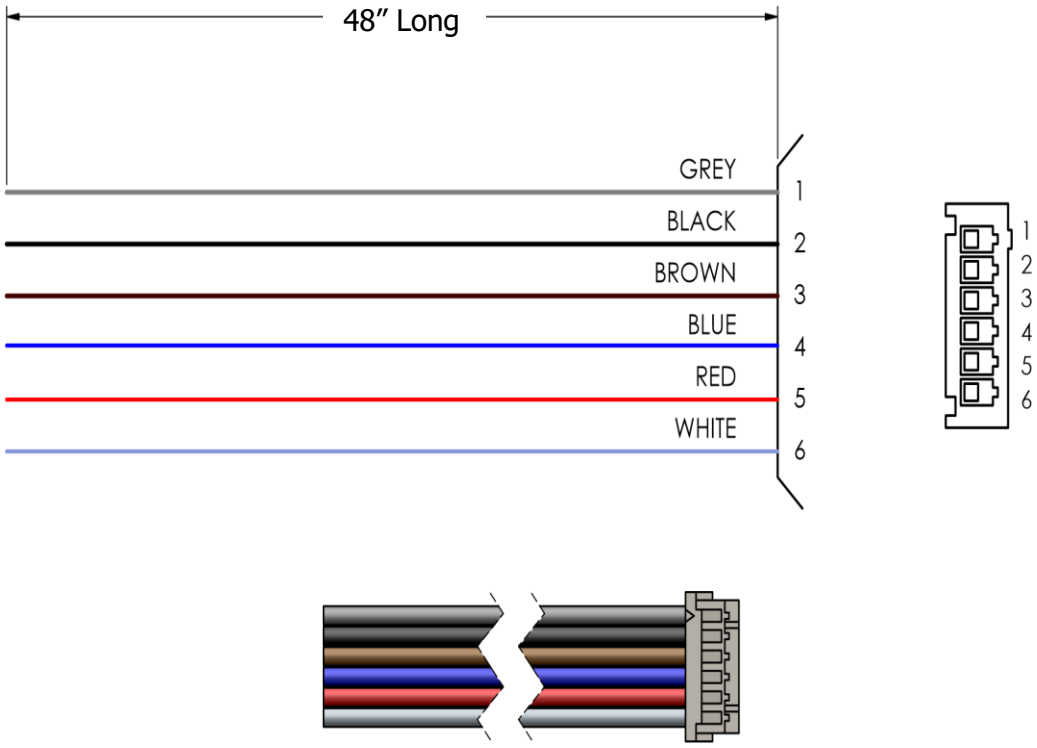
Place a drop or two of cleaner on the tissue (never directly onto the lens) and then wipe the lens in a circular motion, beginning in the center and working your way outward, removing any marks or smear.

Do not use acetone; it could have adverse effects on the plastic, as well as the optical coatings.

Avoid touching the lens with fingers, as this will leave oily smudges. Using household window cleaners is not recommended on coated optics. Use dedicated lens-cleaning solutions, alcohol, or de-ionized water.

18 Diagrams - Wiring and Pinouts

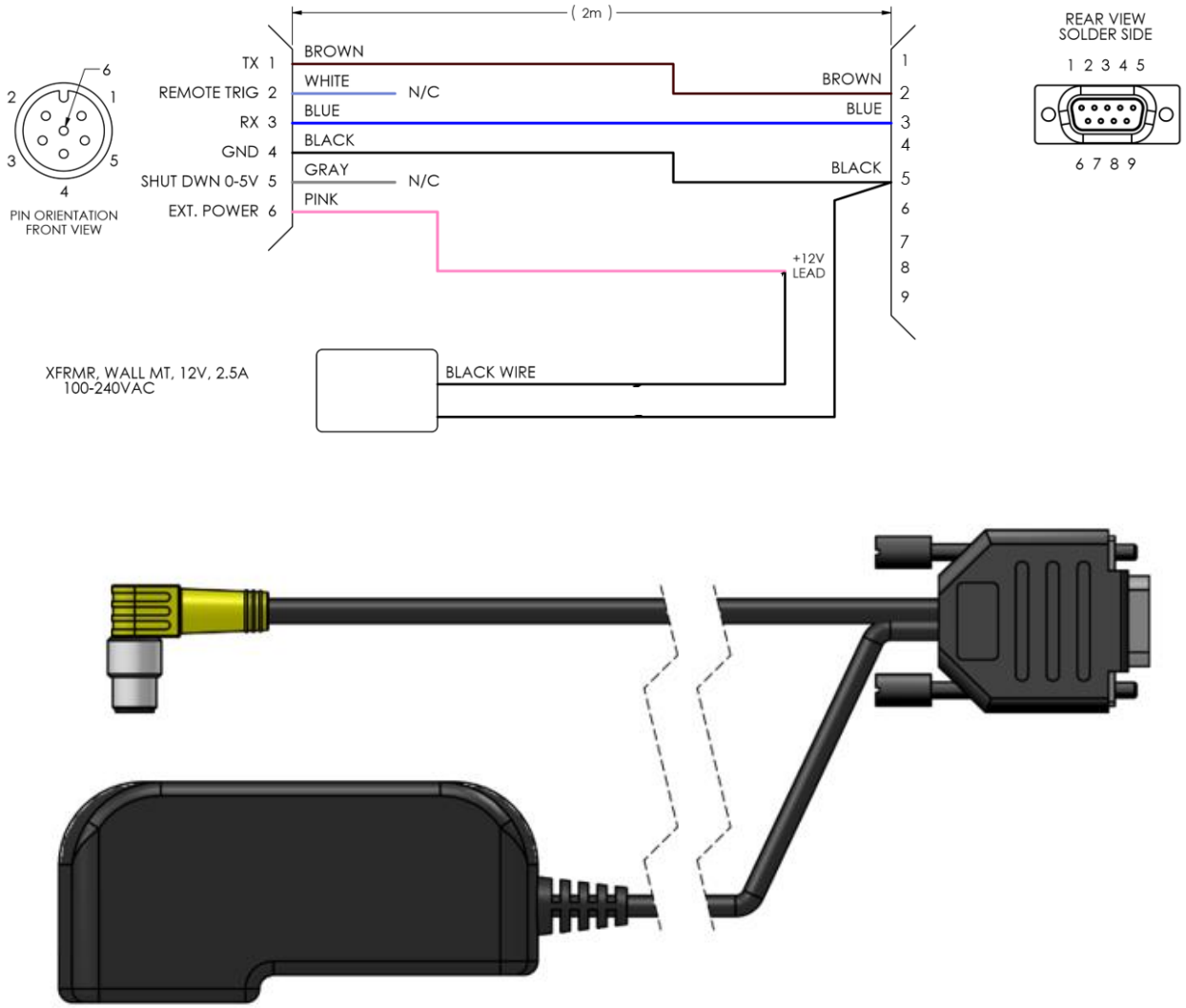
7054674 OEM Cable



PIN #	Wire Color	SX00	SX10	SX30
1	Grey	SHTDWN	SHTDWN	+4-20 Loop
2	Black	GND	GND	GND
3	Brown	RS232 TX	RS232 TX	RS232 TX
4	Blue	RS232 RX	RS232 RX	RS232 RX
5	Red	+12-24 VDC	+12-24 VDC	+12-24 VDC
6	White	TRIG/SDI-12	TRIG/SDI-12	-4-20 Loop

Drawing 11

7054671 External Cable: 12 V Power Download Cable

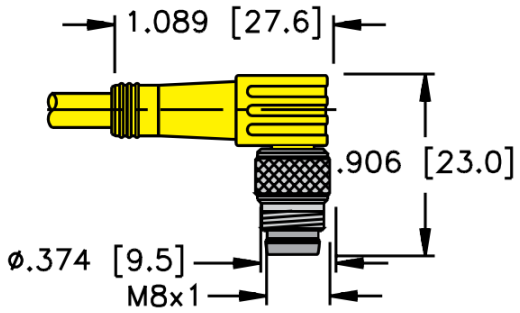


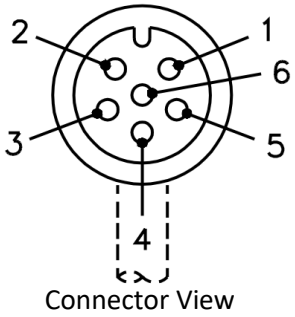
Drawing 22

4824758 Integration Cable with Leads

4824758 Cable (manufacture part number: PSW 6M-2/S90/S618/S771 TK)

Description: 6-conductor cable plus foil shield and drain wire, 2 meters cable length with right angle connector.



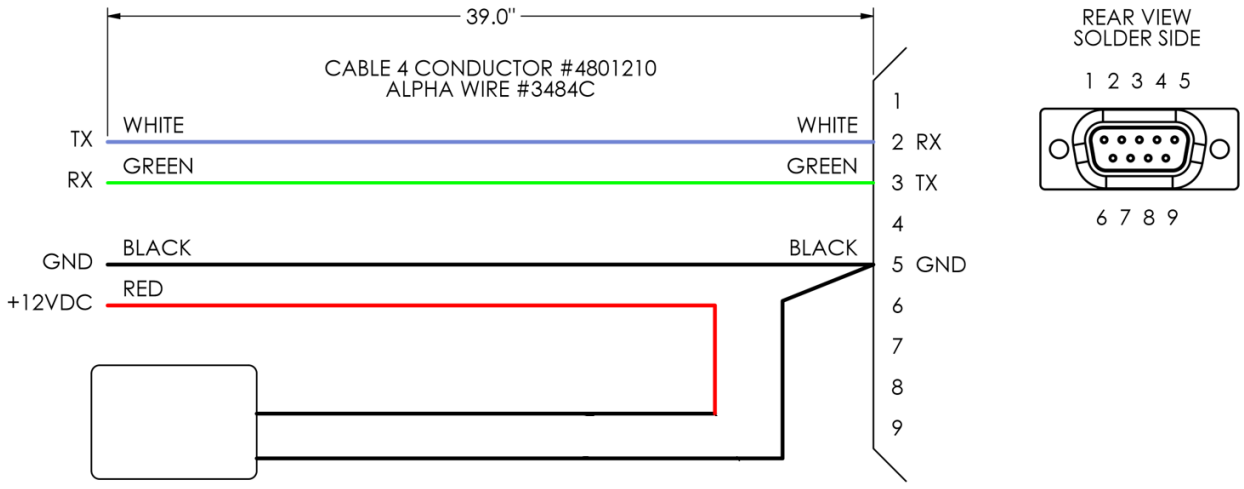


Connector View

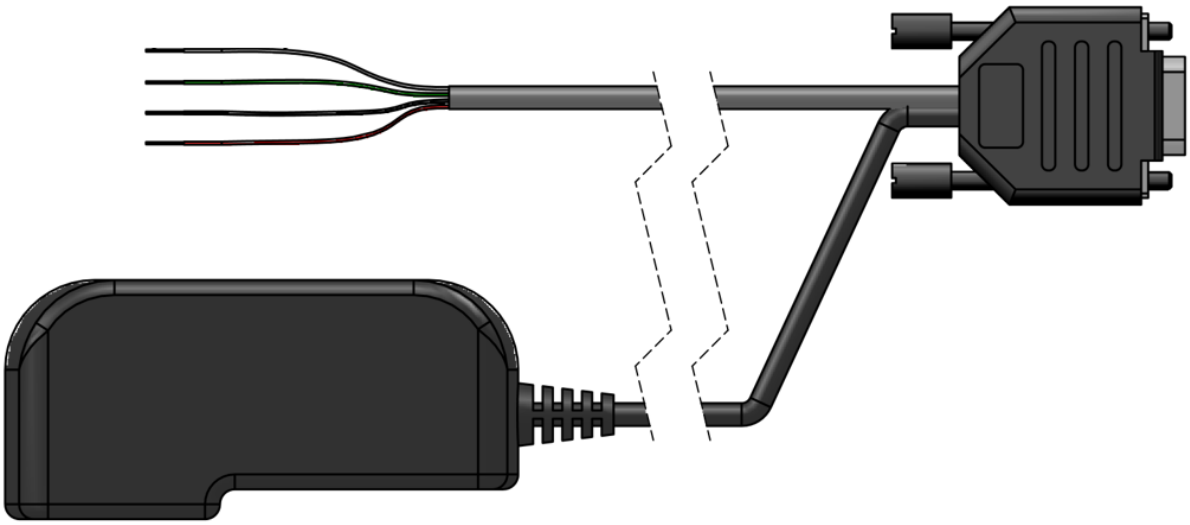
PIN #	Wire Color	SX00	SX10	SX30
1	Brown	RS232 TX	RS232 TX	RS232 TX
2	White	TRIG/SDI-12	TRIG /SDI-12	4-20(-)
3	Blue	RS232 RX	RS232 RX	RS232 RX
4	Black	GND	GND	GND
5	Grey	SHTDWN	SHTDWN	4-20(+)
6	Pink	+12-24 VDC	+12-24 VDC	+12-24 VDC

Drawing 3: Flying Lead Cable

7054691 External Cable: Ruggedized Enclosure Terminal Block Cable



XFRMR, WALL MT, 12VDC,2.5A
INPUT, 100-240VAC

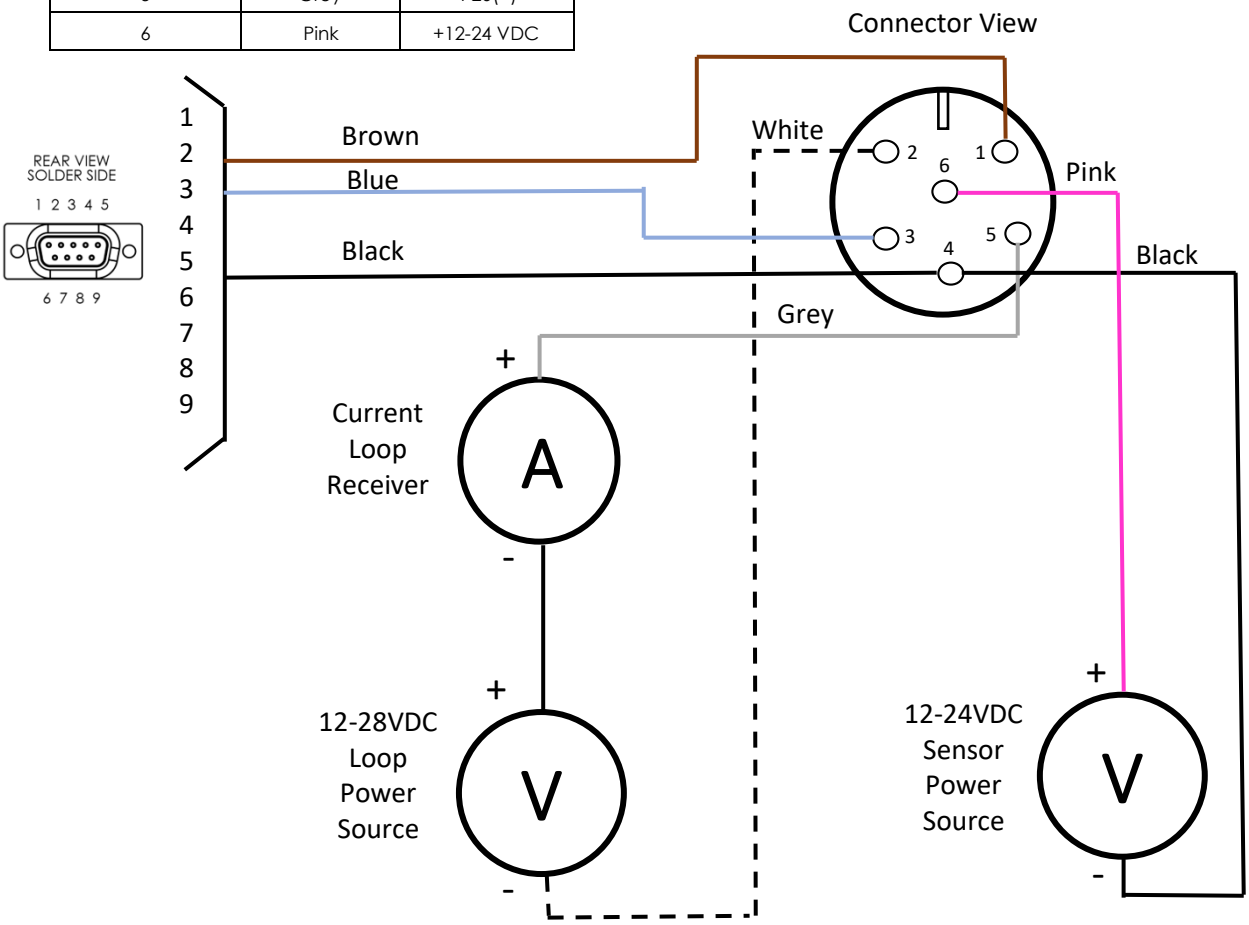


Drawing 4: External Cable Rugged Enclosure

S330 4-20mA Current Loop Wiring Cable with Optional RS-232

Wiring with cable 4824758

Sensor Connection Table		
PIN #	Wire Color	S330
1	Brown	RS232 TX
2	White	4-20(-)
3	Blue	RS232 RX
4	Black	GND
5	Grey	4-20(+)
6	Pink	+12-24 VDC

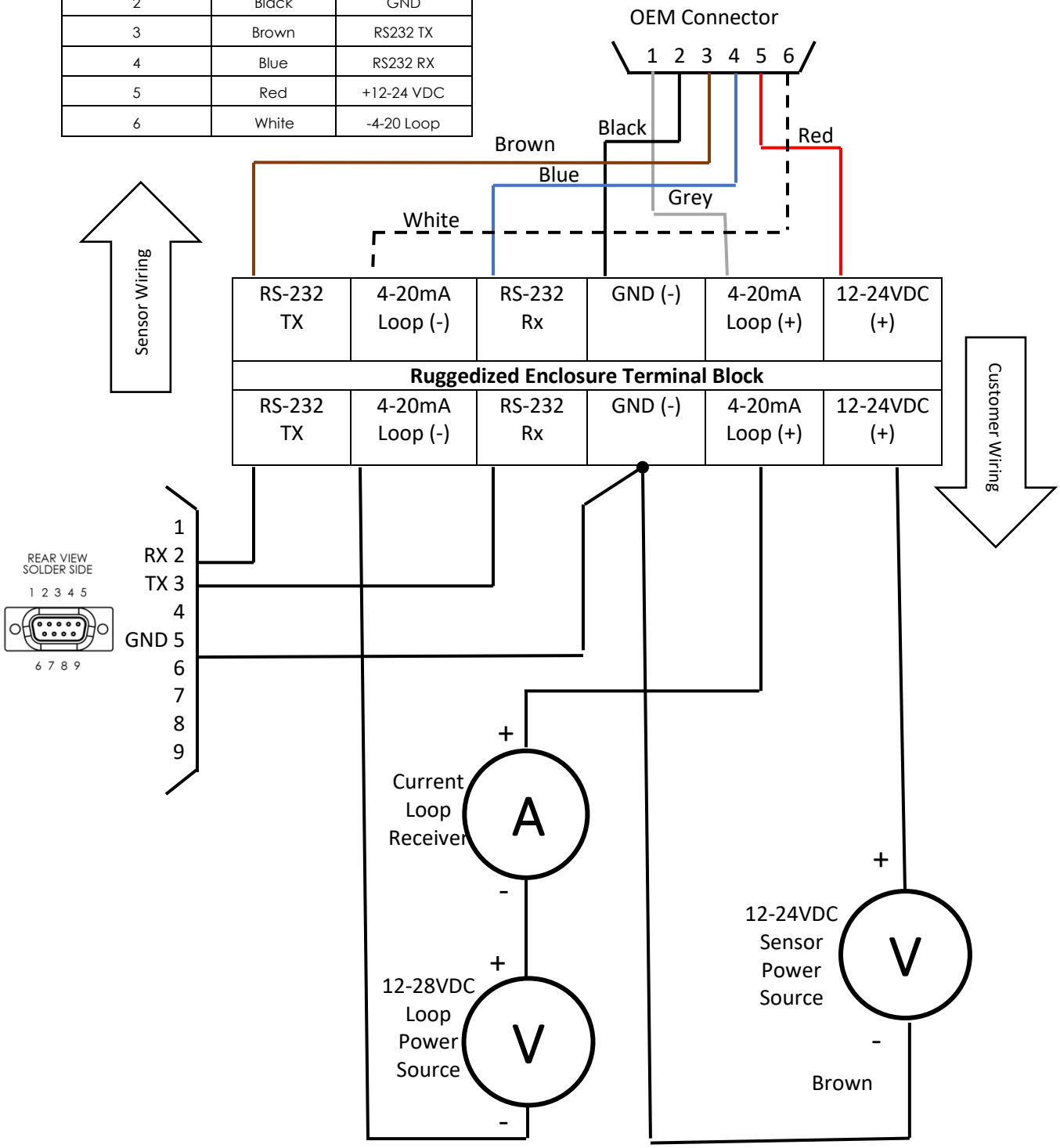


Drawing 5: 4-20mA Cable

S330 4-20mA Current Loop Wiring with Optional RS-232 for Ruggedized Enclosure Terminal Block

Wiring with cable 7054674

Sensor Connection Table		
PIN #	Wire Color	S330
1	Grey	+4-20 Loop
2	Black	GND
3	Brown	RS232 TX
4	Blue	RS232 RX
5	Red	+12-24 VDC
6	White	-4-20 Loop



Drawing 6: S330 4-20 Ruggedized Enclosure Terminal Block

S300 / S310 I/O Trigger Cable Wiring with Optional RS-232

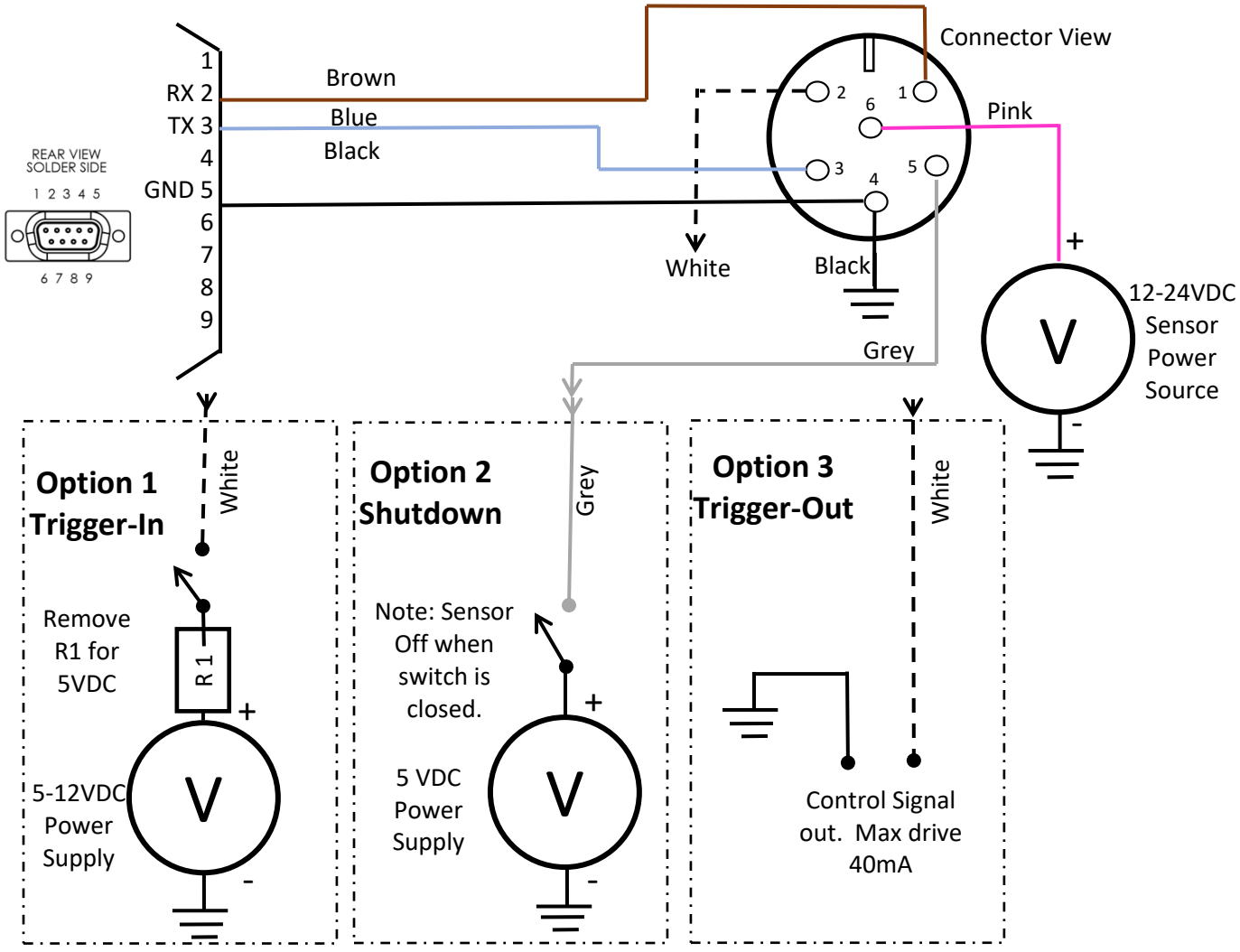
Wiring with cable 4824758

Sensor Connection Table		
PIN #	Wire Color	S300/S310
1	Brown	RS232 TX
2	White	TRIG
3	Blue	RS232 RX
4	Black	GND
5	Grey	SHTDWN
6	Pink	+12-24 VDC

There are three option available for Pins 2 (See serial command $TG)

IMPORTANT: Only use one Optional wiring 1 or 3 below per sensor.

1. **Trigger-In** (See $TG) Note: R1 is 1.2KOhm 5% - ¼ W (Optional if 5VDC)
2. **Shutdown** Note: Power voltage 5VDC
3. **Trigger-Out** (See $TG) Note: Maximum drive is 5VDC at 40mA.



Drawing 7: S300 / S310 I/O Trigger Cable

S300/S310 I/O Trigger Cable Wiring with Optional RS-232 for Ruggedized Enclosure Terminal Block

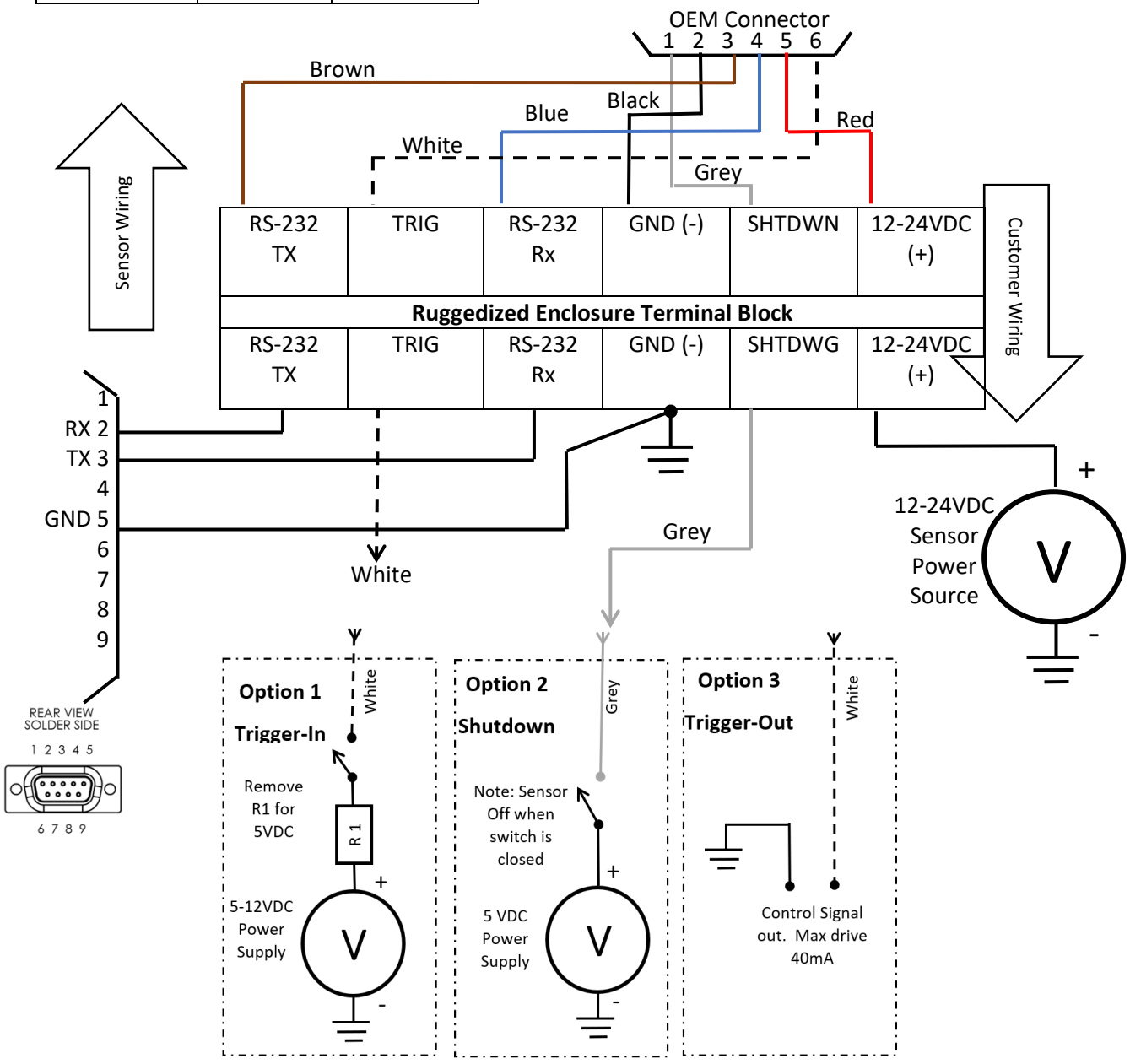
Wiring with cable 7054674

Sensor Connection Table		
PIN #	Wire Color	S330
1	Grey	SHTDWN
2	Black	GND
3	Brown	RS232 TX
4	Blue	RS232 RX
5	Red	+12-24 VDC
6	White	TRIG

There are three option available for Pins 2 (See serial command $TG)

IMPORTANT: Only use one Optional wiring 1 or 3 below per sensor.

1. **Trigger-In** (See $TG) Note: R1 is 1.2KOhm 5% - ¼ W (Optional if 5VDC)
2. **Shutdown** Note: Power voltage 5VDC
3. **Trigger-Out** (See $TG) Note: Maximum drive is 5VDC at 40mA.

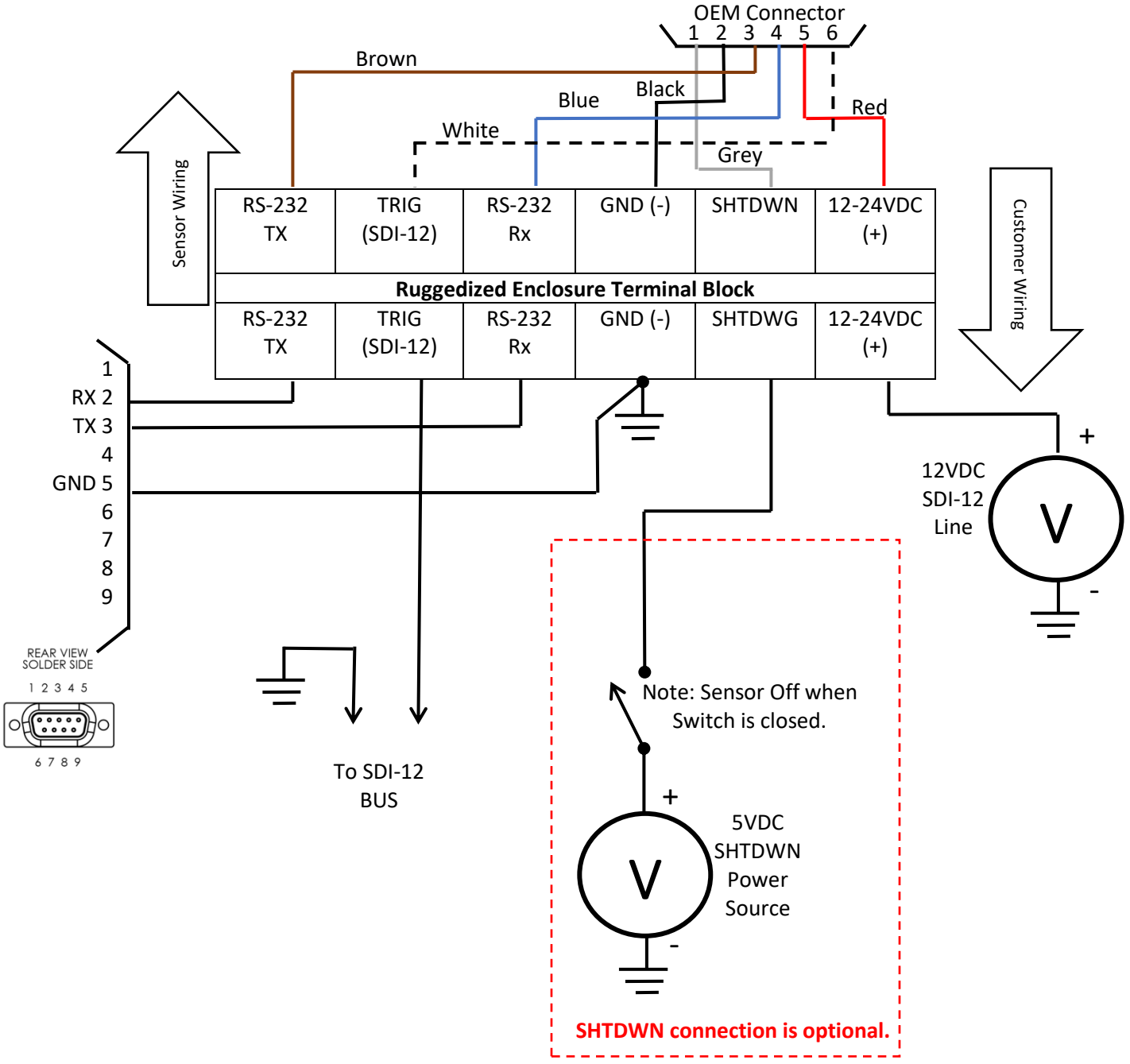


Drawing 8: S300 / S310 I/O Trigger Ruggedized Enclosure Terminal Block

S300 / S310 SDI-12 Cable Wiring for Optional RS-232 for Ruggedized Enclosure Terminal Block

Wiring with cable 7054674

Sensor Connection Table		
PIN #	Wire Color	S330
1	Grey	SHTDWN
2	Black	GND
3	Brown	RS232 TX
4	Blue	RS232 RX
5	Red	+12-24 VDC
6	White	TRIG/SDI-12

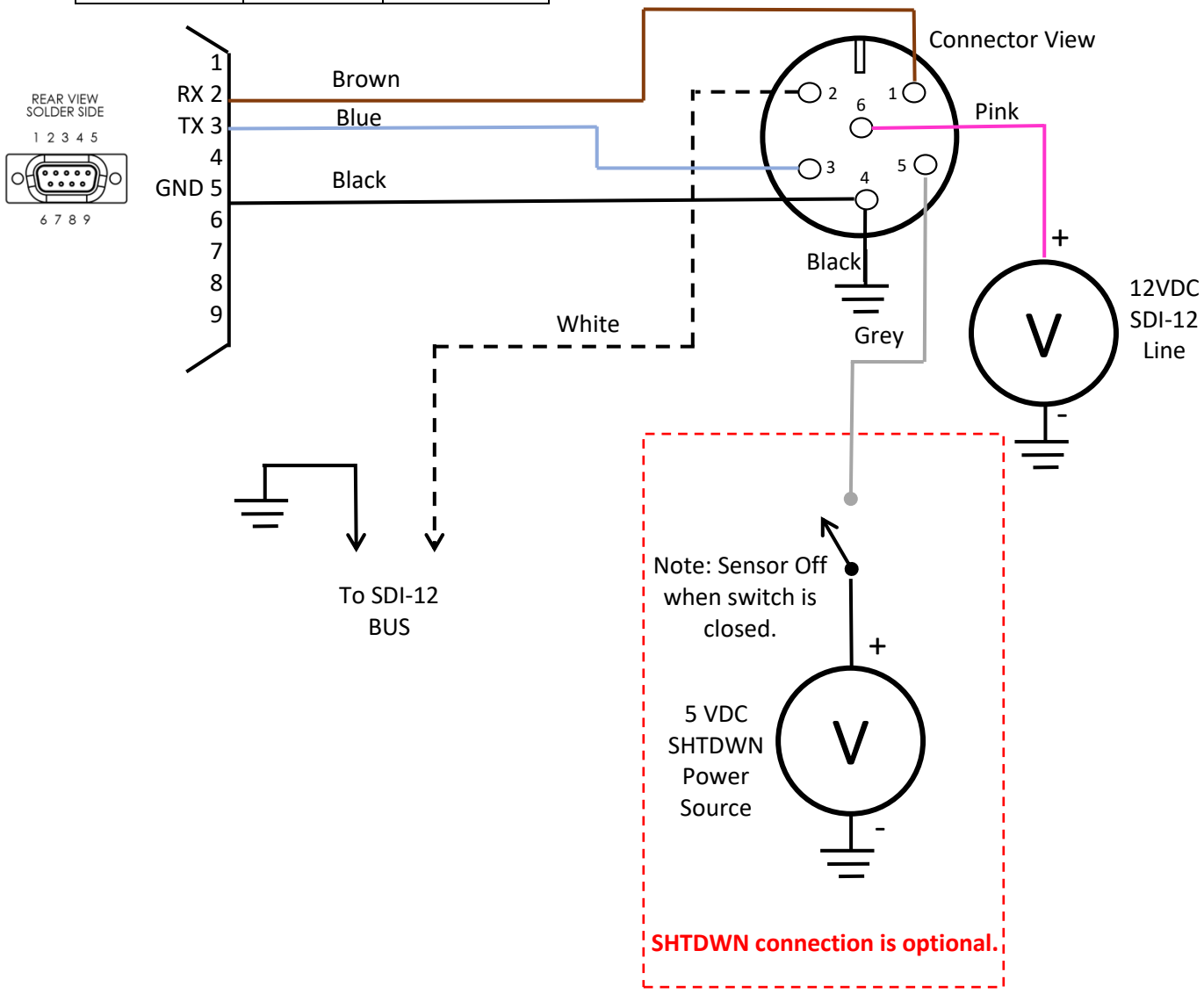


Drawing 9: S300 / S310 SDI-12 Ruggedized Enclosure Terminal Block

S300 / S310 SDI-12 Cable with Optional RS-232

Wiring with cable 4824758

Sensor Connection Table		
PIN #	Wire Color	S300/S310
1	Brown	RS232 TX
2	White	TRIG(SDI-12)
3	Blue	RS232 RX
4	Black	GND
5	Grey	SHTDWN
6	Pink	+12-24 VDC



Drawing 3: S300 / S310 SDI-12 Cable with Optional PC Connec

19 Diagrams - Mechanical

Ruggedized Enclosure Outside Dimensions

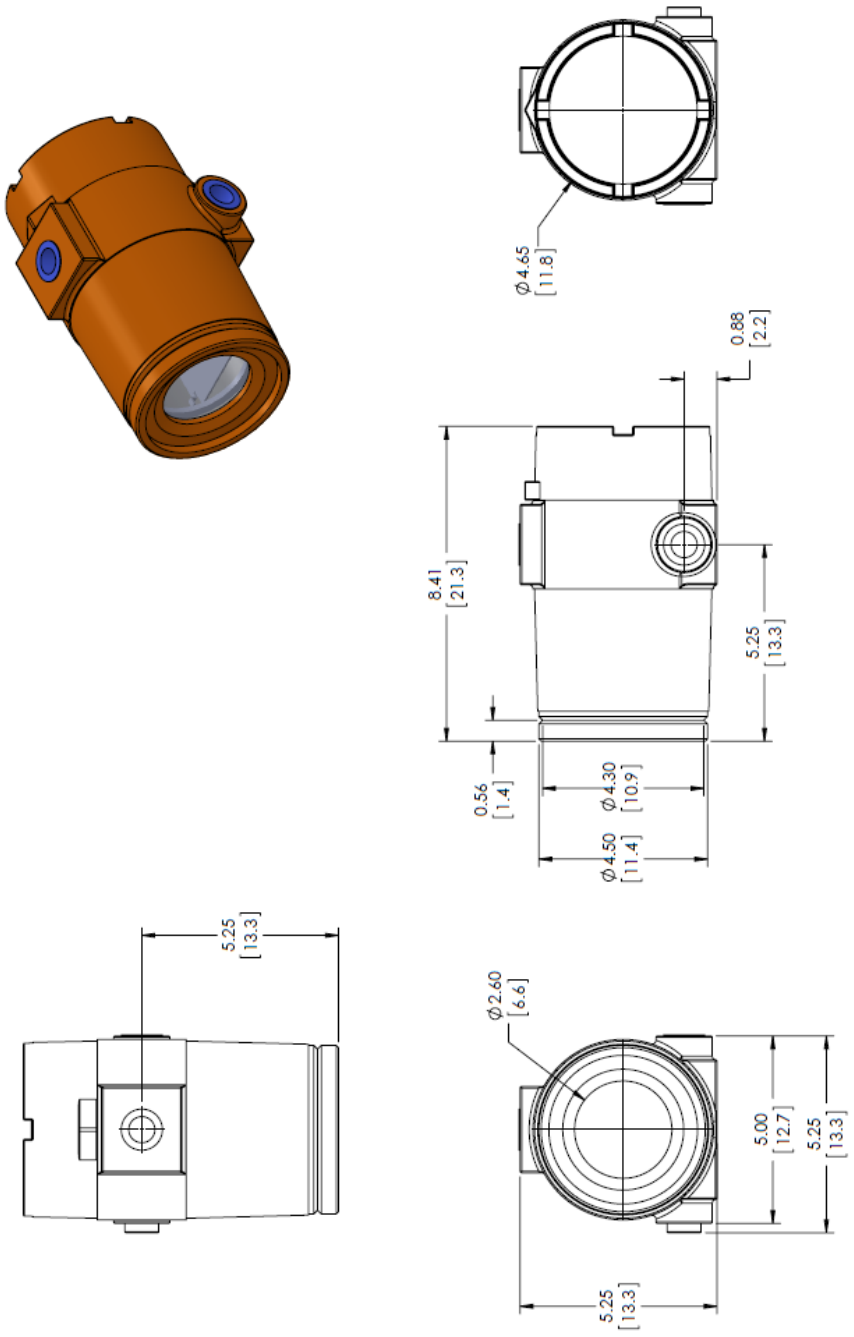
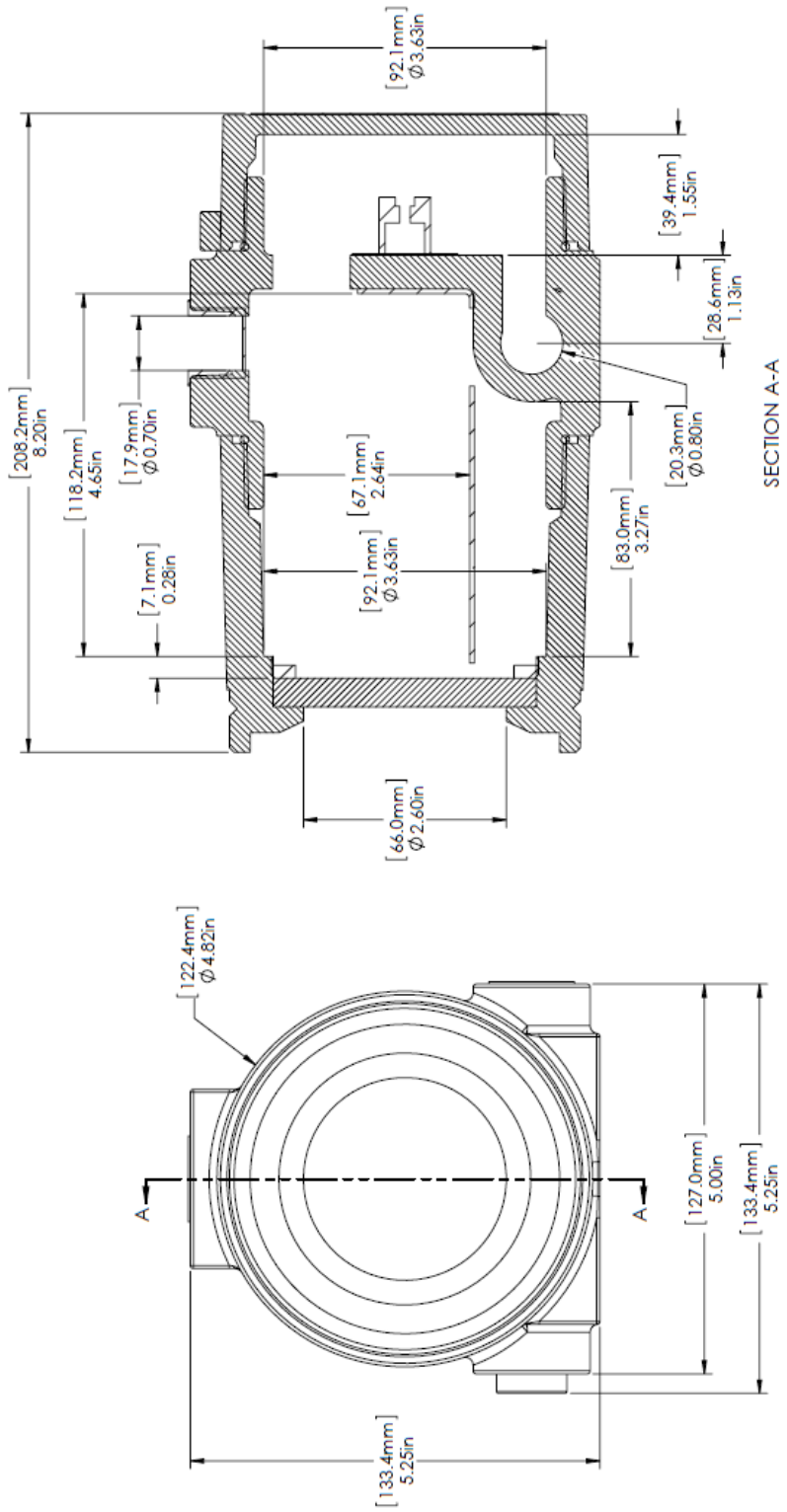


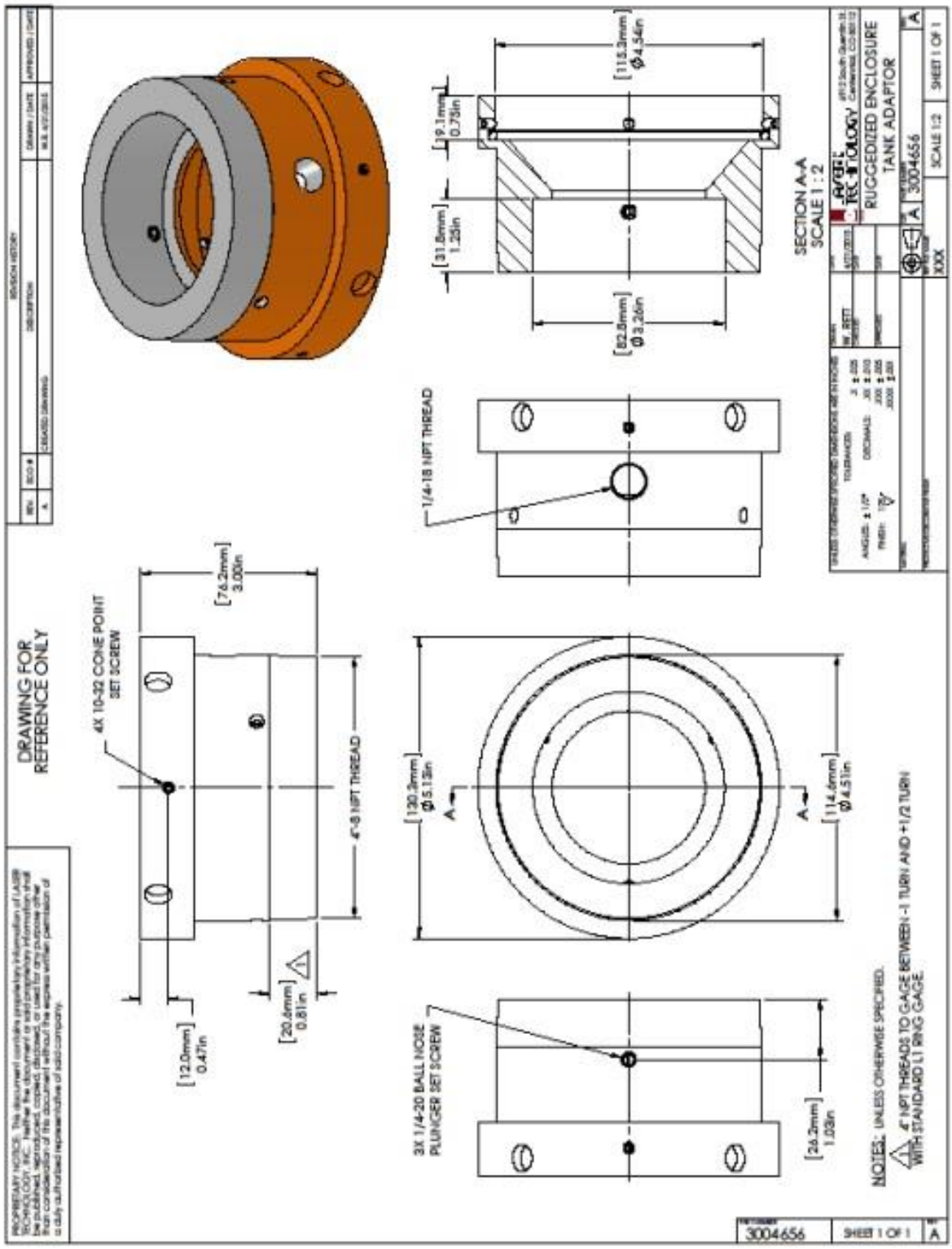
Figure 11: Drawing 4: Rugged Housing Outside Dim.

Ruggedized Enclosure Inside Dimensions



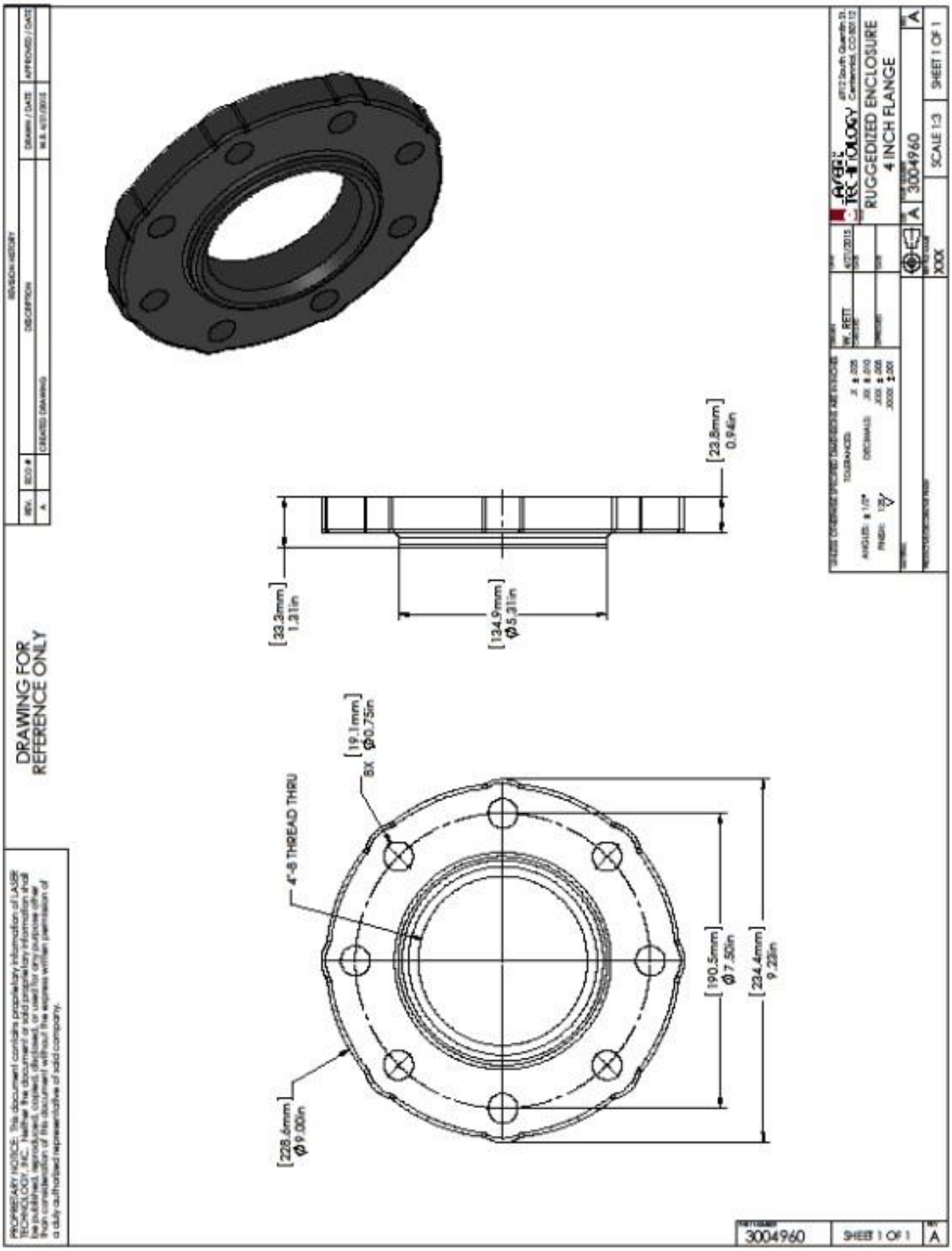
Drawing 5: Rugged Housing inside Dim.

3004956 Tank Adaptor



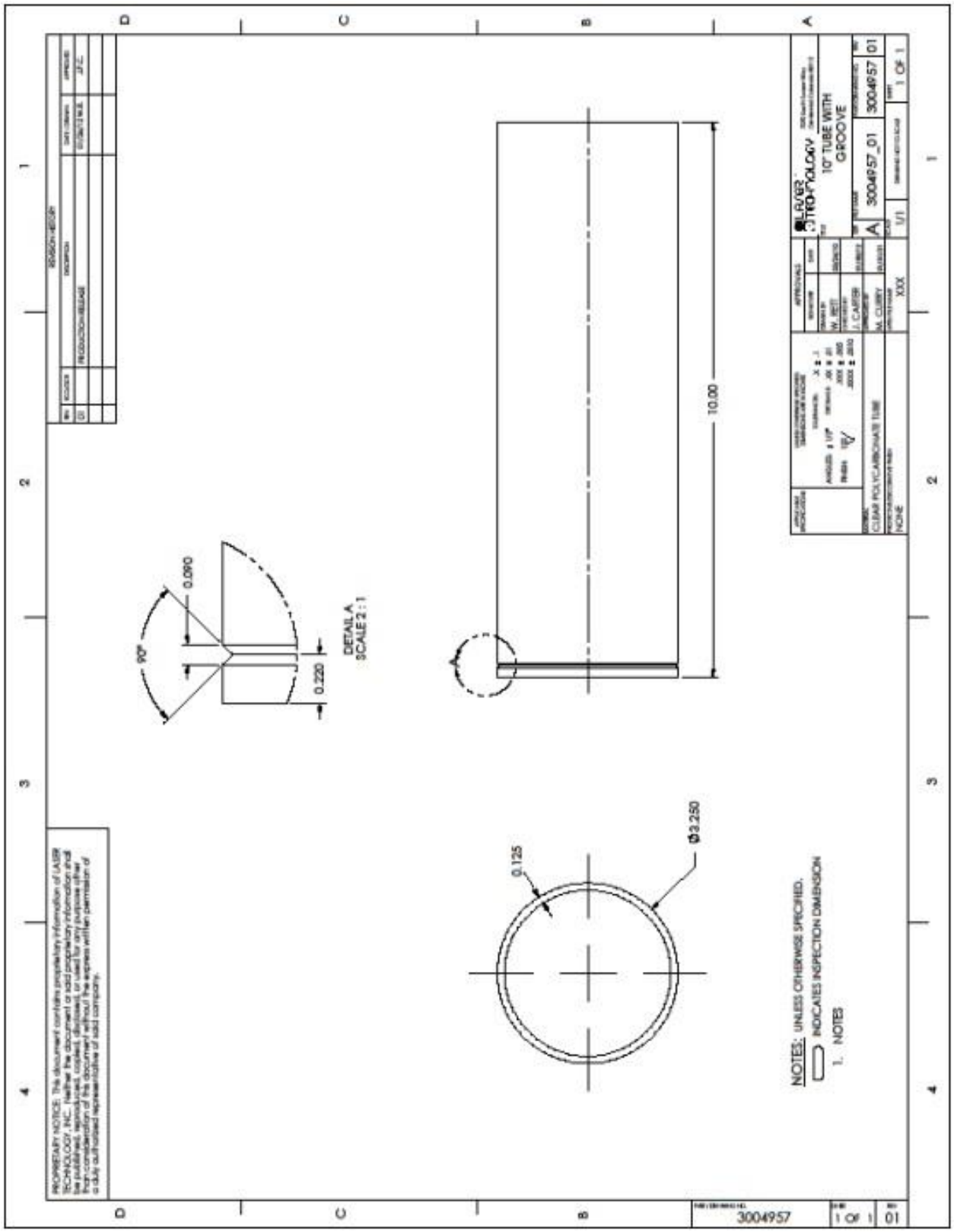
Drawing 13: Adaptor

3004960 4 Inch Flange



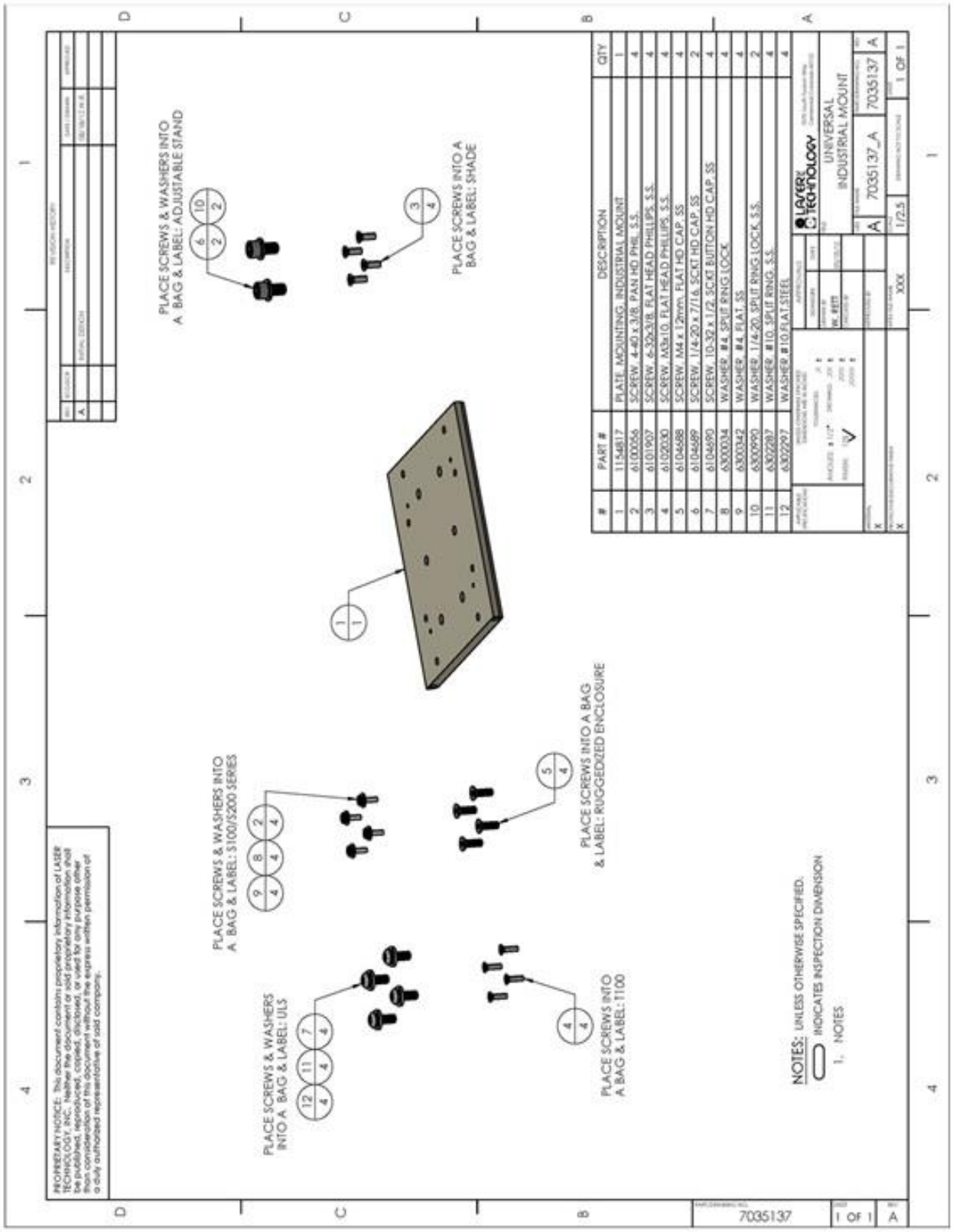
Drawing 14: Flange

3004957 Dust / Splash Tube



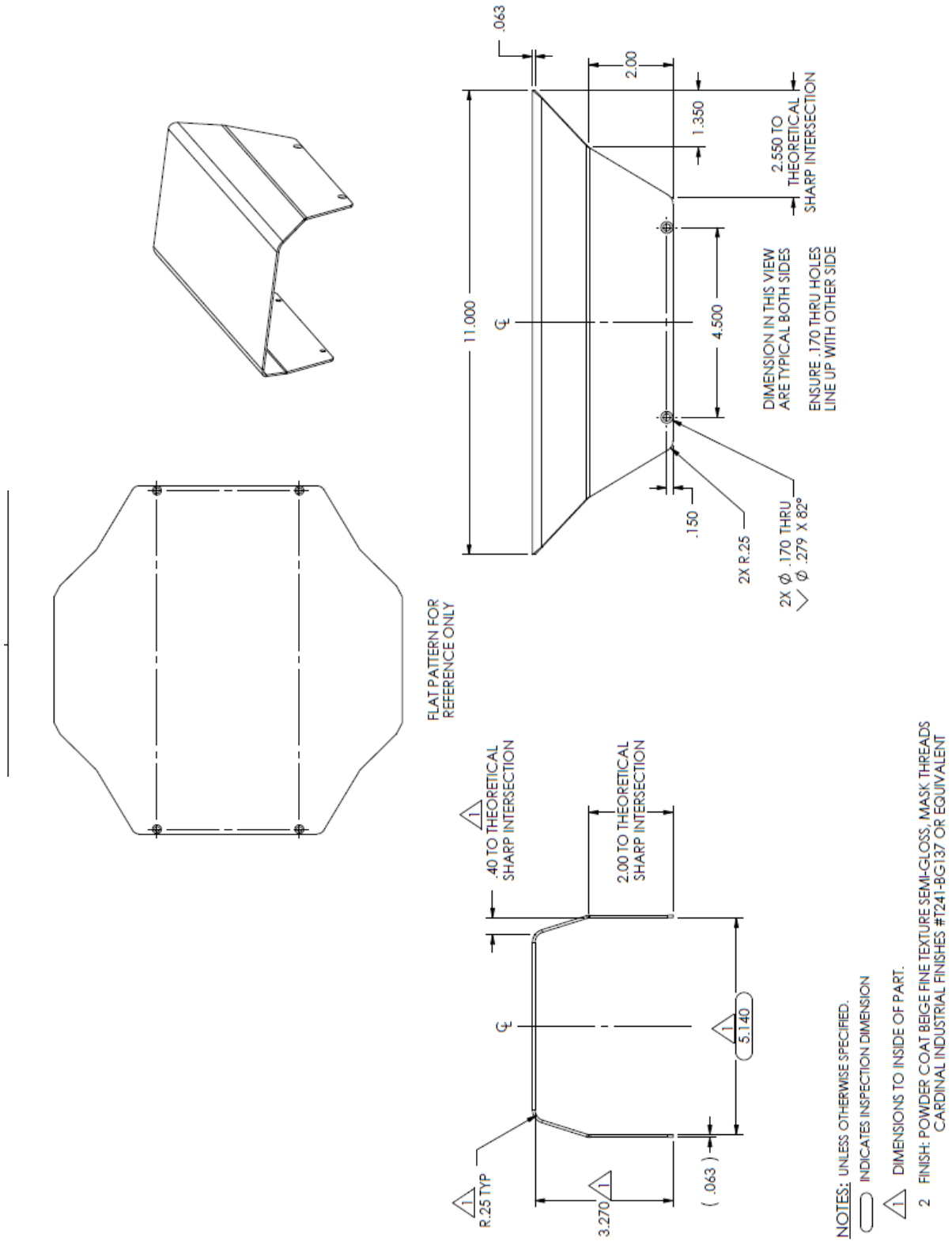
Drawing 15: Dust / Splash Tube

77035137 Mounting Plate



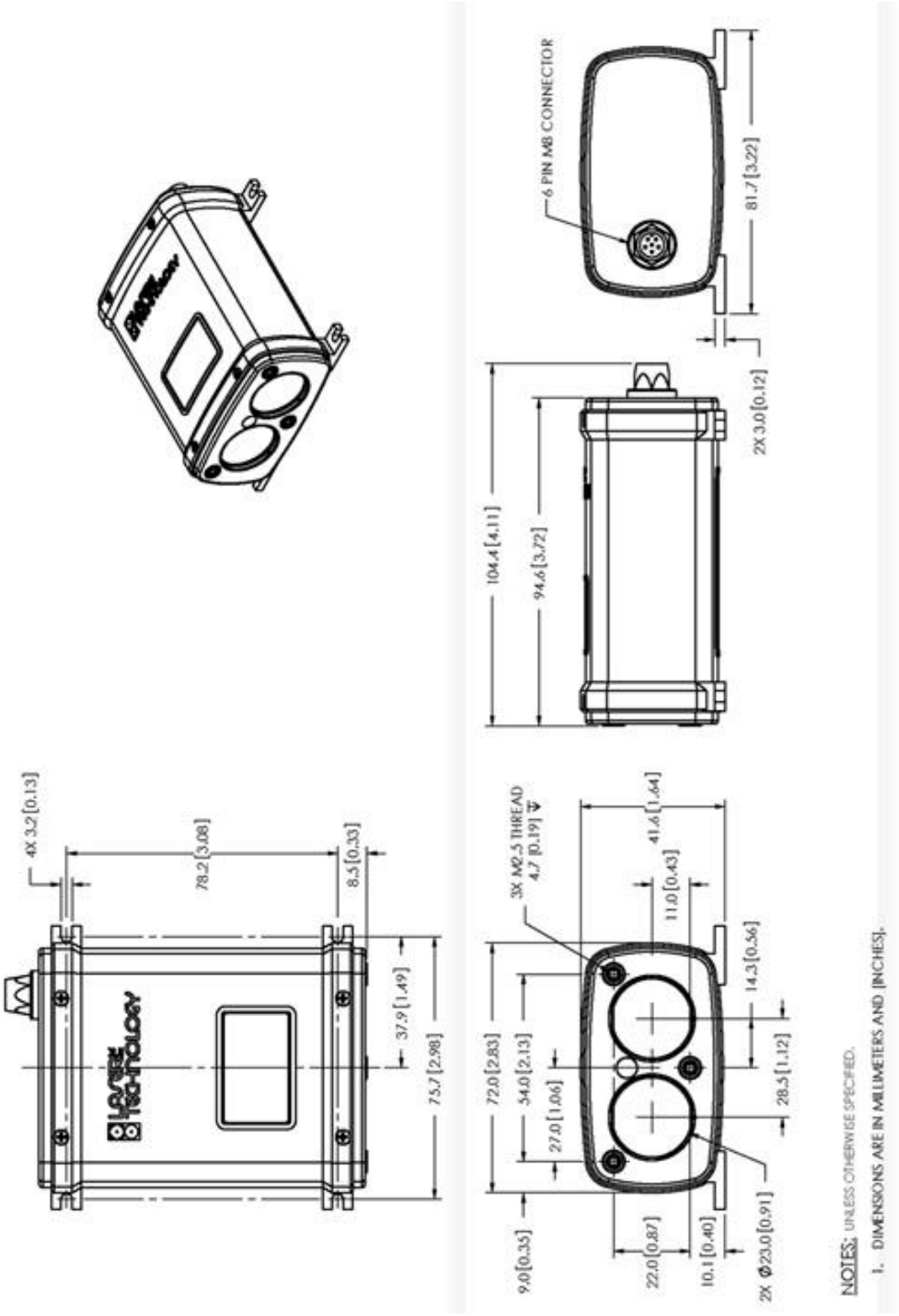
Drawing 16: Mounting Plate

1134749 Sun Shade Industrial Mount



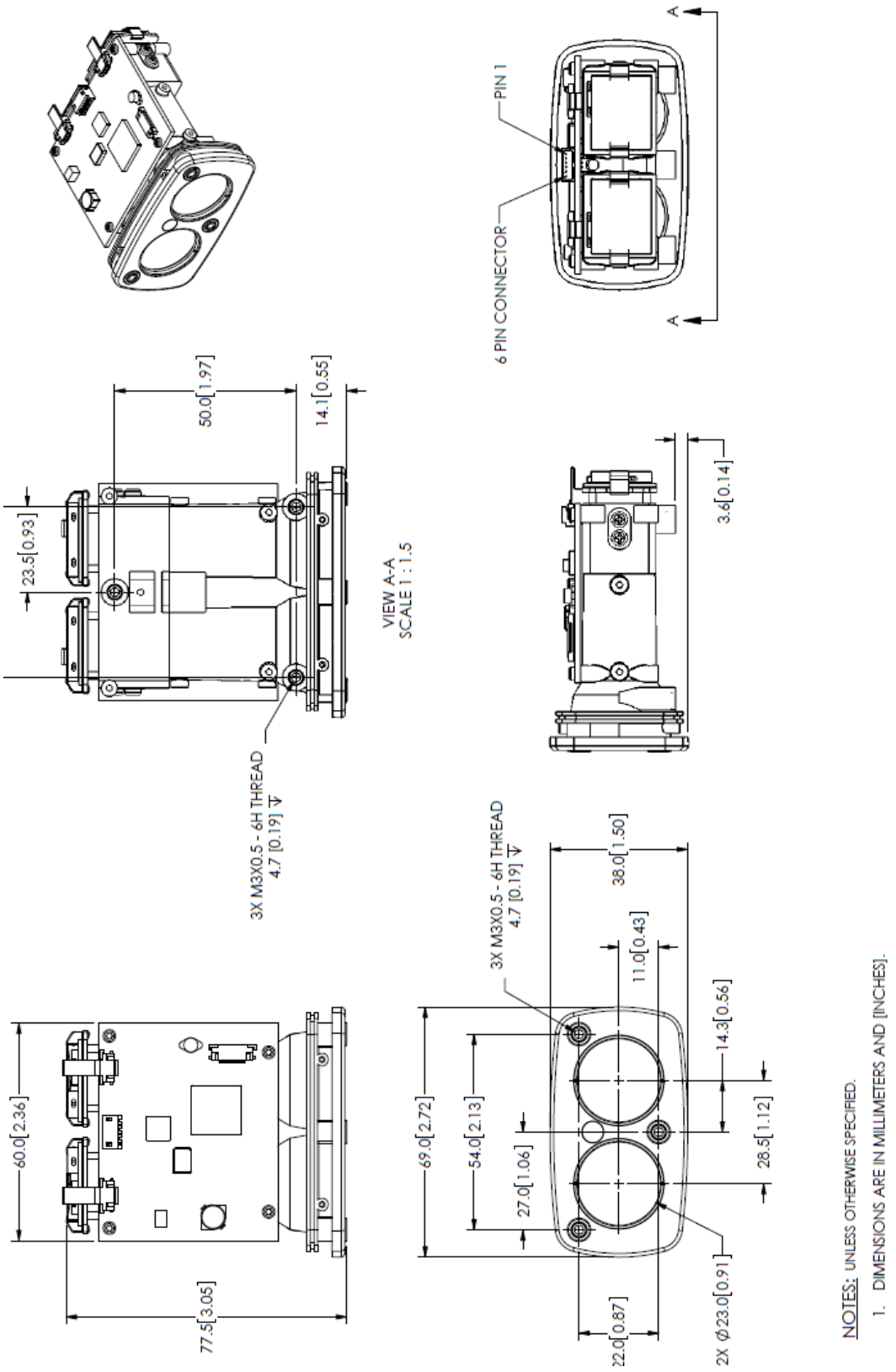
Drawing 17: Sun Shade

Housed Model Dimensions without Lenses



Drawing 18: Housing Dimensions

OEM Model Dimensions



Drawing 19: OEM Dimensions

20 Definitions

Accuracy: also referred to as absolute accuracy, the degree of conformity of a measurement to a standard or a true value (compare with Relative Accuracy).

Angle of Incidence: the angle which an incident line or ray makes a perpendicular to the surface at the point of incidence.

Blanking Distance: A term usually associated with ultrasonic sensors, it refers to the minimum distance a sensor can measure a valid target.

Bulk Density: the ratio of the weight of a material to its volume. This ratio is usually expressed in lbs/ft3 or grams/cm3.

Converge: two or more light rays proceeding inward toward a point.

Cooperative target: a highly reflective surface or object, such as a reflector, designed to reflect light back to a source.

Crest: The crest is the top of a dam, dike, weir, or spillway, which water must reach before passing over the structure. (The highest elevation reached by flood waters flowing in a channel is also called the crest.)

Dielectric Constant: a physical property of all materials, this refers to the material's ability to conduct or hold an electric charge.

Diffuse reflection: a light striking a target and being scattered over a wide angle.

Distance Span: the total distance between the sensor's faceplate and the furthest distance intended to be measured. The Distance Span = the Instrument Offset + the Measurement Span.

Diverge: two or more light rays proceeding outward from a point.

Electrostatic Discharge (ESD): A transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field.

ESD-Protective Material: Material capable of one or more of the following characteristics: limiting the generation of static electricity; safely dissipating electrostatic charges over its surface or volume; or providing shielding from ESD spark discharge or electrostatic fields.

ESD-Protective Packaging: Packaging with ESD-protective materials to prevent damage to ESDS items.

ESD Sensitive (ESDS) Items: Electrical and electronic parts, assemblies and equipment that are sensitive to ESD voltages.

Eye safe: lasers emitting energy with no hazards to the human eye.

Flow Characteristic: refers to the material's ability to flow easily and uniformly.

Frequency: the number of repeating events per unit of time. A 14 Hz laser firing rate means a laser is firing 14 times per second.

Gage height: also known as Stage, it is the height of the water in the stream above a reference point. Gage height refers to the elevation of the water surface in the specific pool at the stream gaging station, not along the entire stream. Gage height also does not refer to the depth of the stream. Measurements of gage height are continually recorded by equipment inside a gage-house on the streambank.

Harsh ambient conditions: the challenging atmosphere between the sensor and a target.

Infrared light: invisible light with wavelengths roughly between 700 nm and 1550 nm.

Instrument Offset: allows the user to add or subtract a fixed constant to the measurement. An offset is generally used to compensate for the sensor being in a different location from the desired zero point of an intended target. An offset value can be a positive or negative number.

Laser: acronym for light amplification by stimulated emission of radiation. A device that produces a monochromatic coherent beam of light by energizing atomic energy levels.

Lens: an optical element that converges or diverges light.

Maximum range: the maximum distance the sensor can acquire a measurement.

Measurement Span: the distance between the maximum (full) and minimum (empty) levels of the intended target.

Minimum range: accuracy may be compromised if a measurement is made from less than this distance.

Non-contact: a measurement made without a sensor touching the target. A preferred measurement method in many applications.

Non-Cooperative target: a target not designed to reflect light and that has less than 90% reflectivity.

Opacity: the degree to which light is not allowed to travel through.

Parallax: displacement or difference in a focus along two different optical axes; e.g., closing the left eye and viewing an object with the right eye-the object will appear to shift when the right eye is closed and viewed with the left eye.

Precision: the repeatability of a series of test results; whether the method gives the same answer under the same set of circumstances or sampling criteria.

Reflectance: the fraction of incident light returned by a surface. Higher target reflectance will increase range. General surface reflectance (R) ratios are: reflective=90+%, white=90%, gray=20%, black=5%.

Refraction: the change in direction of light as it passes from one medium to another of a different density; e.g., from air to liquid surface.

Refractive Index: also known as the Index of Refraction**,** a dimensionless number that describes how fast light propagates through the material. It is defined as where c is the speed of light in a vacuum and v is the phase velocity of light in the medium.

Relative Accuracy: also referred to as Repeatability or Precision, it is the sensor's ability to measure to the same target, under the same conditions, over and over again, and produce the same measurement reading.

Resolution: the minimum distance between two adjacent features or objects or the minimum size of a feature or object that can be detected. For a measurement, it is the smallest unit of resolve; for example, 0.001 meter has 1 millimeter of resolution. Not to be confused with accuracy.

Sample rate: the frequency with which the sensor updates its range output. This can be set as low as one sample every 30 seconds and as high as 14 samples per second for the TruSense 300 series.

Span: the minimum and maximum range of a sensor to a target in which a valid measurement can be returned.

Stilling Well: a circular pipe that is installed in a tank or connected to a canal, ditch, or stream by an inlet pipe. A float in the well is sometimes coupled to a stream data recorder in order to obtain water stage data that is not affected by surges or choppy water that may occur in the channel.

Target: term used to refer to an object or point that is being measured or detected.

Wavelength: one wavelength. equals the distance between two successive wave crests or troughs; e.g., 905 nanometers defines this distance is 0.000000905 meters between two adjacent points on the same light wave.

21 Appendix A – Ruggedized Enclosure for the TruSense S300 Series

US Ratings for Enclosure:

Division Ratings

Classified

Class I, Div 1 Groups B, C, D
Class II, Div 1 Groups E, F, G
Class III
Type 4x

Zone Ratings

Class I, Zone 1, AEx d IIC
Ex d IIC
Class III
Type 4x
Approved Instrument Housing
Class I, Div 1 Groups B, C, D FM 3615
Class II, Div 1 Groups E, F, G
Type 4x

Global Ratings

ATEX (flameproof–DEMKO)
II 2G Ex d IIB+H2
II 2D Ex tD A20
IP66
IECEx (flameproof–UL)
Ex d IIB+H2
IP66 IEC60529

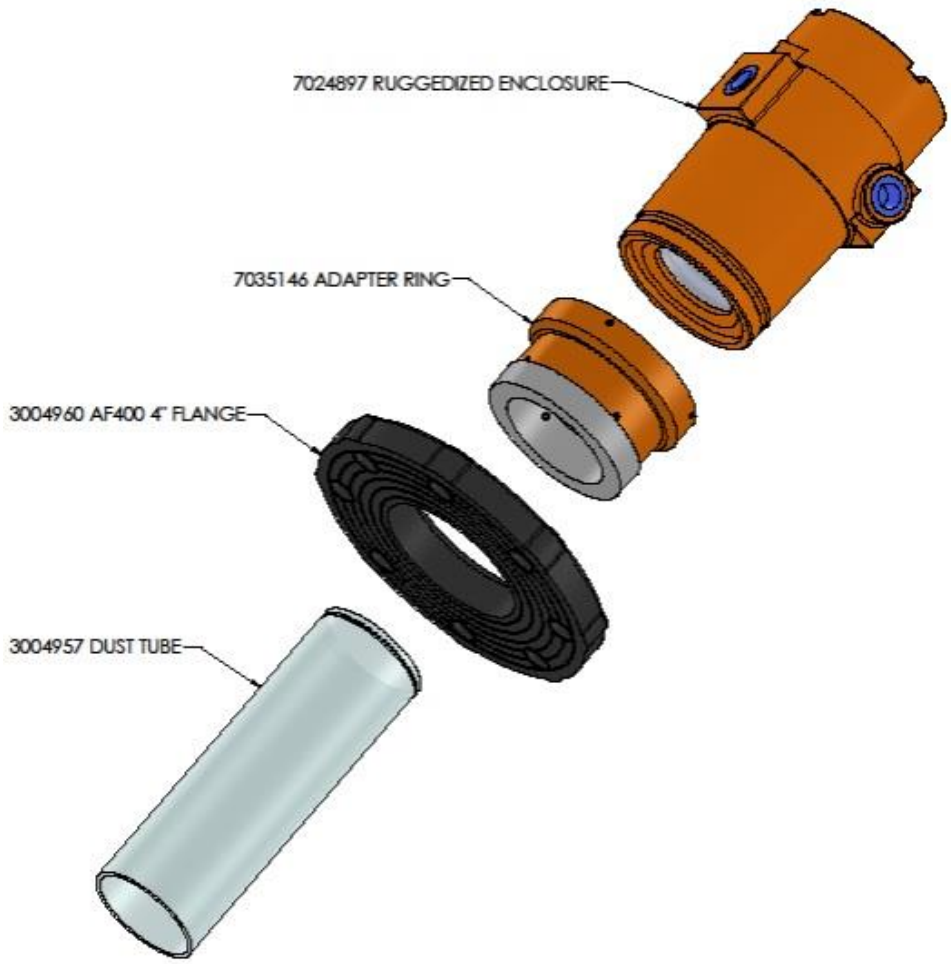
Physical

Weight: 8 lbs (3.62kg)
Dimensions: 5 in diameter x 10 in long (12.7 x 25.4 cm)
Conduit fitting: 3/4 in NPT

The Ruggedized Enclosure components:

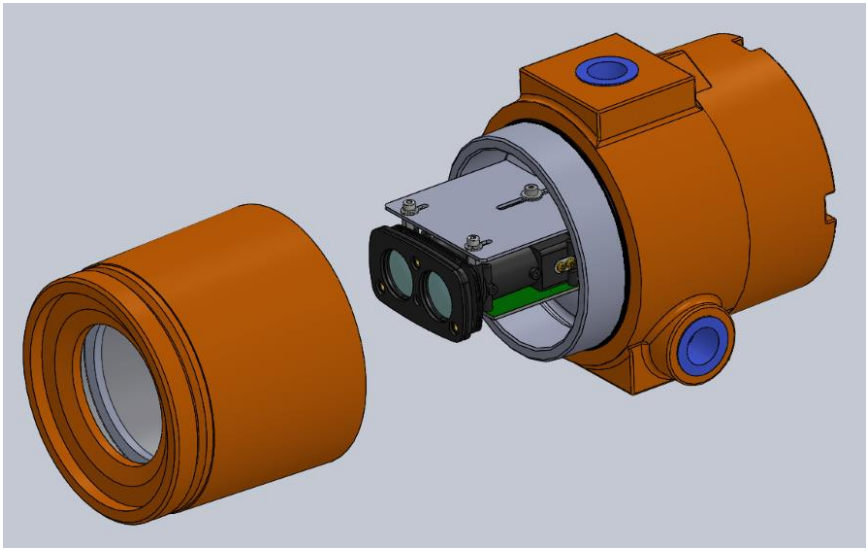
Enclosure, Adapter, Flange and Dust Tube

These parts can be purchased separately. The flange and dust tube require the tank adapter.



The S300 series sensor mounted inside the enclosure:

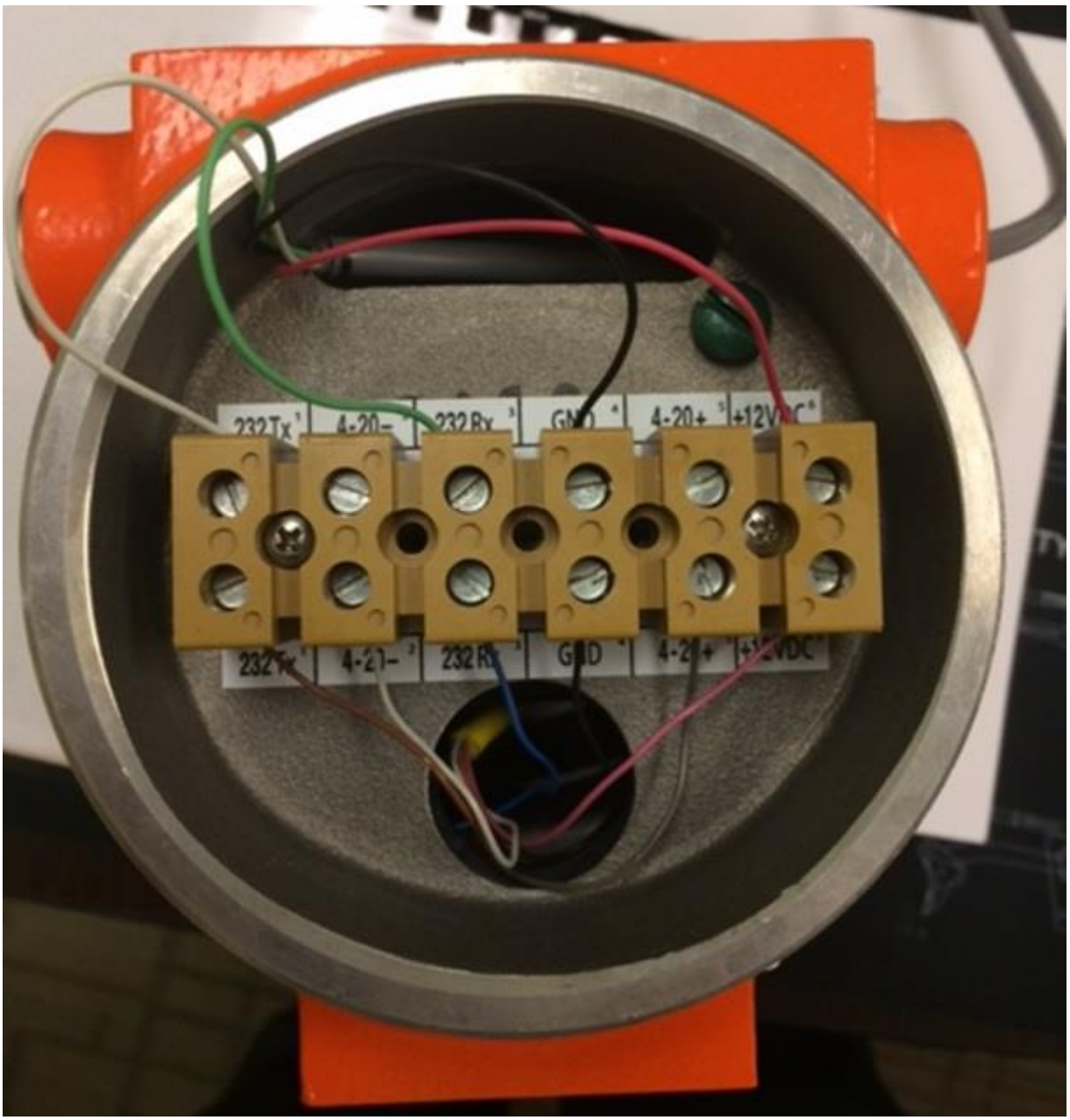
Note, the diffusing lens option can be added to this configuration. Sensors ordered with the ruggedized enclosure will be installed at the factory to ensure proper alignment and fit.



Ruggedized Enclosure Parts List

	Description	Part Number
	Ruggedized Enclosure	7024897
	Tank Adaptor	7035146
	4-inch Flange	3004960
	Dust/Splash Tube	3004957
	Spanner Wrench	9034501

Ruggedized Enclosure Terminal Block



Ruggedized Enclosure Installation Instructions & Cautions

Fold and place this in the rear terminal block location of the Ruggedized Enclosure prior to shipping

IMPORTANT

- Do not open the sensor (window) side of Ruggedized Enclosure. This side of the Enclosure is locked at the factory. Failure to comply with this will result in sensor damage and voids the warranty

- Only open the decal side or back of the Enclosure for wiring

- If using the Tank Adaptor, completely seat home the Ruggedized Enclosure into the Tank Adaptor before securing the set screws around the Tank Adaptor. Push firmly on top of the Ruggedized Enclosure until it seats completely past the Tank Adaptor o-ring and is level in the Tank Adaptor-when enclosure is completely seated home into the Tank Adaptor-secure the set screws (4 each with a 3/32" Allen Wrench) around the Tank Adaptor to firm (do not over tighten)

- (Do not tighten the 3 flat grooved set screws near the 4 inch threaded portion of the Tank Adaptor)

- If using the Dust Tube with the Tank Adaptor, completely seat home the Dust Tube Grooved End into the Tank Adaptor ensuring the part "snaps" into place

- If using the Terminal Block PC cable this is for connecting the Ruggedized Enclosure to a PC and observing the readings and performing configuration changes for setup. This cable is not intended as a permanent field installation cable
- Reference the Diagram section of the User Manual for wiring instructions