

TRUE ECHO[®]

General Purpose
CR-L Radar Liquid Level Sensor

User Manual



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NOTE: Find product specifications, accessories, and more in the Data Sheet. Go to:
<https://apgsensors.com/product/true-echo-cr-l-radar-sensor/>

INTRODUCTION

Thank you for purchasing a TRUE ECHO® CR-L Radar Liquid Level Sensor from APG. We appreciate your business! Please take a few minutes to familiarize yourself with your sensor and this manual.

The TRUE ECHO CR-L radar is a Frequency Modulated Continuous Wave (FMCW) radar operating at 76-81 GHz. It has a maximum measuring range of 49.2 feet (15 m) and a minimum blind zone of 7.87 inches (0.2 m). The TRUE ECHO CR-L brings the accurate level readings of radar sensors to industrial liquid measurements. It can accurately measure in many adverse environments. Its narrow beam can detect small targets and achieve precise positioning with high resolution. All TRUE ECHO CR-L sensors can be easily setup and field adjusted via the TRUE ECHO Bluetooth app.

Reading your label

Every TRUE ECHO sensor comes with a label that includes the instrument's part number, model number, and serial number. Please ensure that the part number on your label matches your order.

Key Features

- Accurate level measurements in various adverse environmental conditions.
- Millimeter wave technology allows higher signal-to-noise ratio and smaller blind zone.
- The 4° antenna beam half angle means the environmental interference has less impact on the sensor and the installation is more convenient.
- Integrated design, small size.
- Chemical resistance
- 4-20mA (2 wire), and RS-485 (4 wire) outputs.
- Bluetooth communication to facilitate on-site personnel maintenance work.

IMPORTANT: FCC regulations require 75-85 GHz radars to be installed to ensure a vertically downward orientation at fixed locations only. They must not operate while being moved or while inside a moving container. Hand-held applications are prohibited as well as marketing to residential consumers.

WARRANTY AND WARRANTY RESTRICTIONS

This product is covered by APC's warranty to be free from defects in material and workmanship under normal use and service of the product for 24 months. For a full explanation of our Warranty, please visit <https://www.apgsensors.com/resources/warranty-certifications/warranty-returns/>. Contact Technical Support to receive a Return Material Authorization before shipping your product back.

Repair and Returns

Should your TRUE ECHO Radar require service, please contact the factory via phone, email, or online chat. We will issue you a Return Material Authorization (RMA) number with instructions. You can also find the form on our website by clicking "RMA" in the web footer, or go to [apgsensors.com/RMA-Form](https://www.apgsensors.com/RMA-Form).

- Phone: 888-525-7300
- Email: sales@apgsensors.com
- Online chat: www.apgsensors.com

Please have your part number and serial number available.

CHAPTER 1: DIMENSIONS AND WIRING

Dimensions

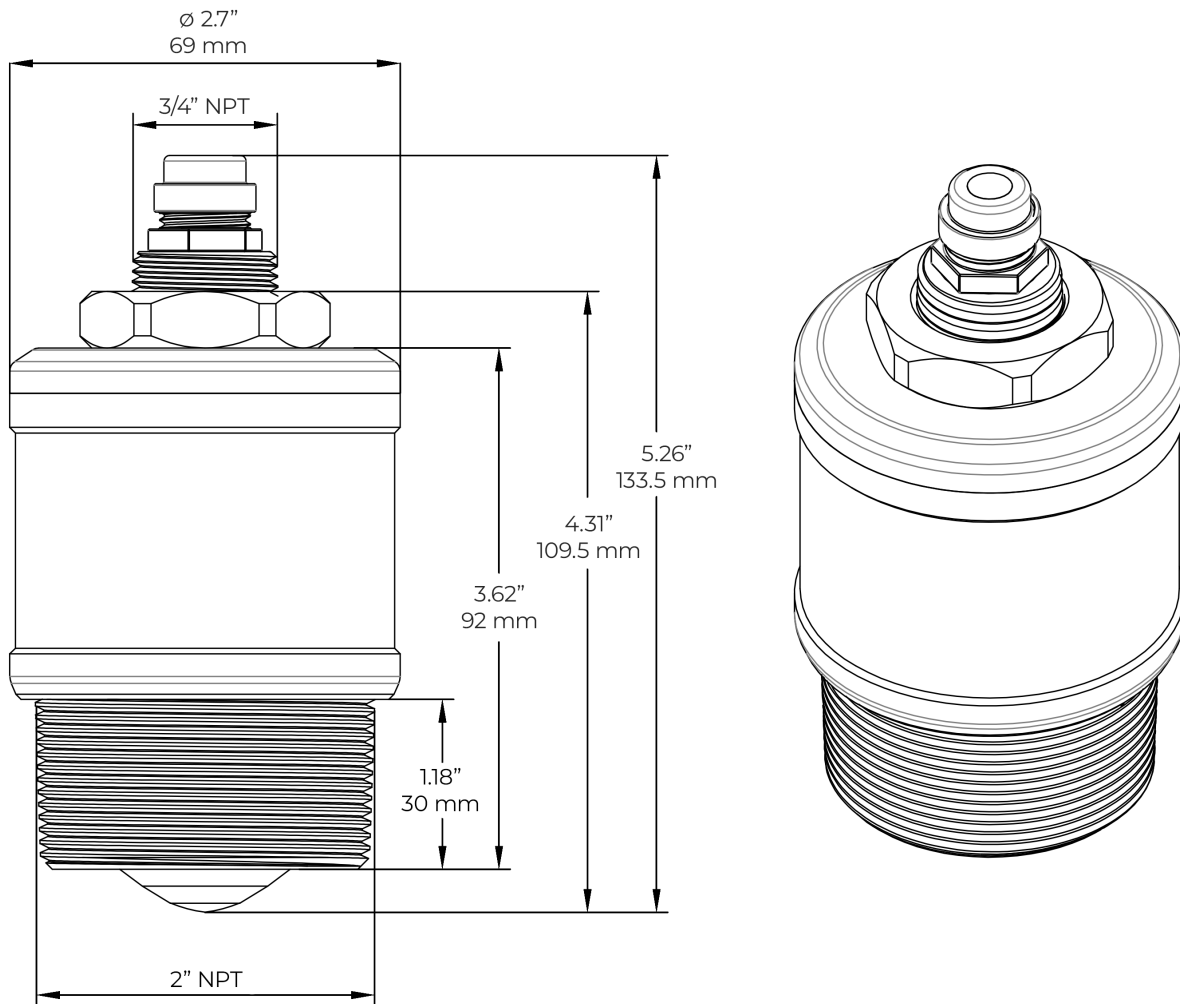


Figure 1.1 TRUE ECHO CR-L General Purpose Radar

Electrical Pinout and Power Supply Tables

Pin Out Tables

	4-20mA
Red	Power Supply VDC +
Black	4-20mA Out
Yellow	Shield, Earth Ground

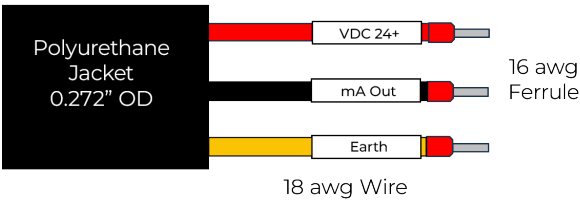


Figure 1.2 4-20mA Wires

	RS-485
Red	Power Supply VDC +
Black	Power Supply Ground -
Blue	RS-485 A+
White	RS-485 B-
Yellow	Shield, Earth Ground

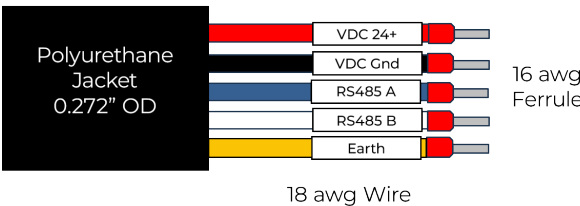


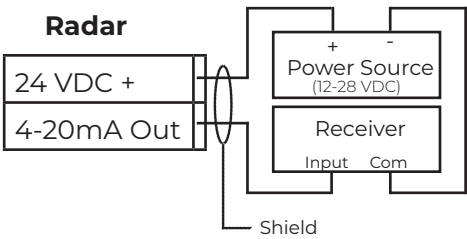
Figure 1.3 RS-485 Wires

Wiring Information

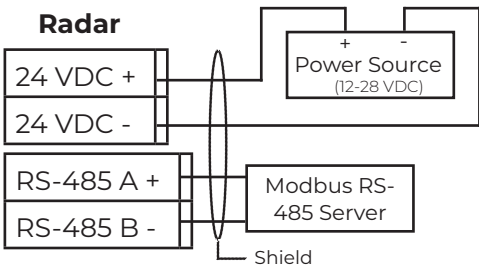
Power Supply Table

Output	Voltage	Typical RMS Current	Peak Current 12.8ms Pulse Every 800ms Update Cycle
4-20 mA	12-28 VDC	4-20 mA	n/a
RS-485	12-28 VDC 24 VDC 12 VDC	-- 5-17 mA 7-21 mA	-- 175 mA 265 mA

4-20mA Connection:



RS-485 Connection:



NOTE: Connect Shield wire to Power Supply Earth Ground.

CHAPTER 2: INSTALLATION AND REMOVAL PROCEDURES

Physical Installation Notes

- The material to be measured must have a dielectric constant greater than 2.
- In areas with direct sunlight, it is recommended to install the instrument in a cool place or use a sun visor to avoid excessive temperature and to provide good ventilation and heat dissipation.
- Mount your TRUE ECHO sensor so that it has a clear, perpendicular path to the surface being monitored.
- Install at least 8 inches from a side wall.
- The radar path should be free from obstructions and as open as possible for the 4° off axis beam pattern. Mount the sensor away from tank or vessel inlets.
- Wrap PTFE tape around threads before installing the radar into the tank opening. This will help it screw in easier. **Do not over tighten.**
- For proper performance and accuracy, do not suspend by cable without the use of the optional weight.
- Be careful not to scratch or damage the radar face.

Tools Needed

- Tools to make electrical connection
- Mobile device with Bluetooth

Mounting Instructions

- STEP 1:** Mount the radar using the 2 inch NPT bottom threads or the 3/4 inch NPT top threads and nut. **Do not over tighten.**
- STEP 2:** Attach the wires to your control system according to the Wire Diagrams on page 2.
- STEP 3:** Power on the radar.
- STEP 4:** Use the TRUE ECHO app to connect to the radar via Bluetooth. See “Programming with the App” on page 6 for more information.

NOTE: For information on mounting bracket accessory options, contact APG.

Sensor Placement

Ensure the radar level transmitter is installed **perpendicular** to the liquid surface. Installing the radar at an angle will weaken the signal amplitude, cause unwanted reflections, and affect the normal range.

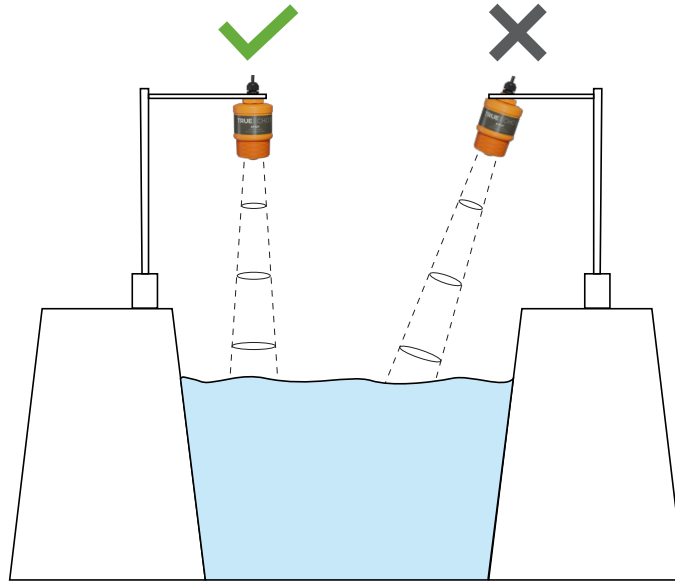


Figure 2.1 Position radar perpendicular to surface.

Ensure that there are no interferences within the beam angle, such as riverbanks, tank walls, ladders, steps, etc.

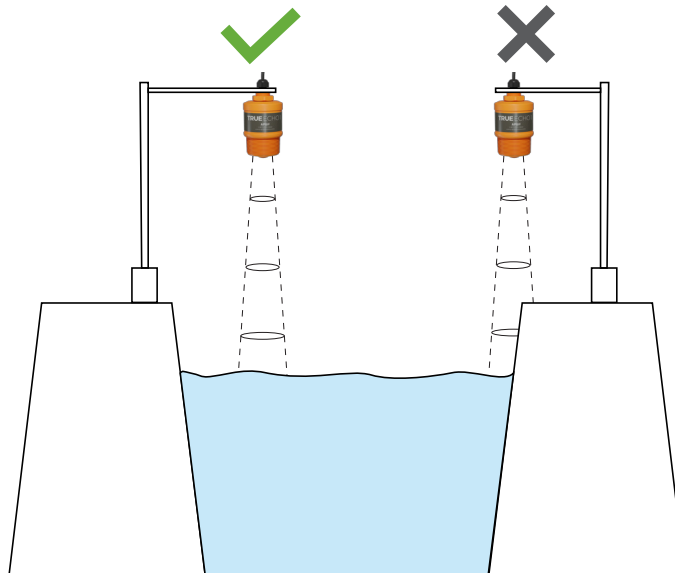


Figure 2.2 Ensure no interference in the beam angle.

Install the radar at least 7.9 inch (20 cm) away from side walls. When installing in wells or pipes, place the radar as close to the center as possible to avoid interference from the walls.

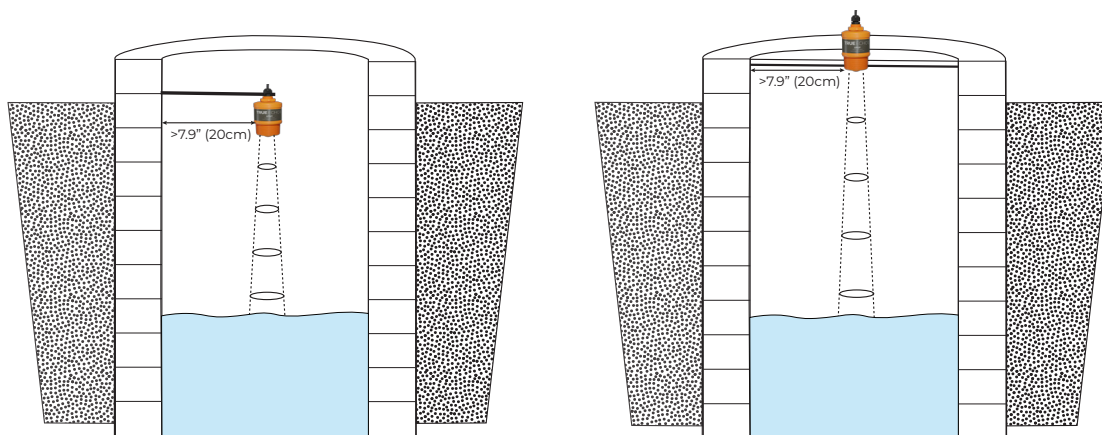


Figure 2.3 Install radar away from walls in wells and pipes.

When installing in tanks with domed lids, install off center to avoid additional false echoes.

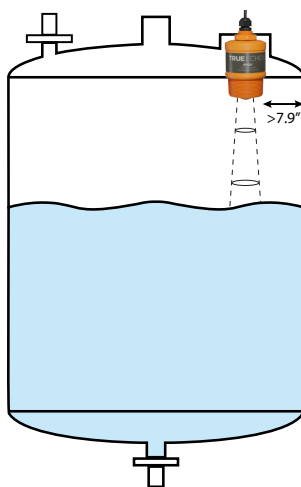


Figure 2.4 Install radar off center in domed tanks, at least 7.9" away from side walls.

Removal Instructions

Removing your radar from service must be done with care.

- STEP 1:** Ensure power is turned off.
- STEP 2:** Disconnect the radar wires.
- STEP 3:** Remove the radar from its mount.
- STEP 4:** Store it in a dry place, at a temperature between -40° to 158°F (-40° to 70°C).

CHAPTER 3: PROGRAMMING WITH THE APP

All TRUE ECHO radar sensors are Bluetooth compatible. To change settings and parameters easily with your mobile device, download the free TRUE ECHO Radar App by searching “TRUE ECHO” in the Apple or Google Play Store.



Figure 3.1 TRUE ECHO app logo

NOTE: If a Location Service prompt is displayed, please select “While using the app”. If a Relative Position prompt is displayed, please select “Allow”. These are required to connect the True Echo App to the radar.

Connect Bluetooth

- STEP 1:** Install the TRUE ECHO app from the app store.
- STEP 2:** Turn on your mobile device’s Bluetooth.
- STEP 3:** Open the TRUE ECHO app. On the Select Device screen, press “General Purpose Radar.”
- STEP 4:** Press the “Set up” button next to the radar’s name.
- STEP 5:** Press “Read” to view current settings in each tab. Press “Write” to save changes.
- STEP 6:** The Distance, Level, and mA readings (for 4-20mA units only) appear in a banner along the bottom of the screen.

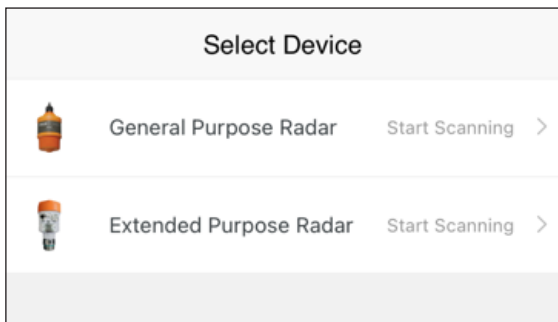
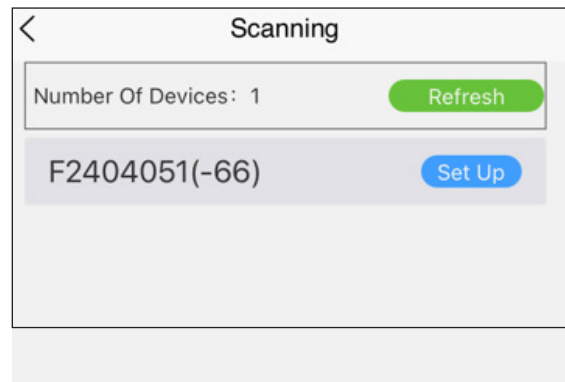


Figure 3.2 Select device type



NOTE: If you don’t see the device on the scanning screen, make sure the radar is wired correctly and powered on. Press “Refresh” to scan for devices.

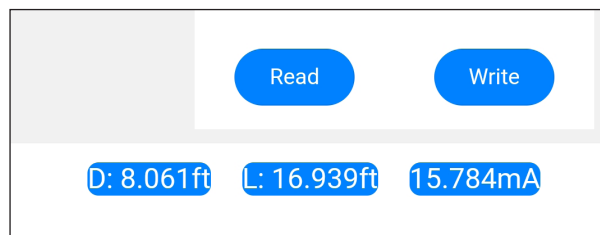


Figure 3.4 Distance, Level, mA reading (for 4-20mA units only)

Programming Quick Start

- STEP 1:** Choose a Vessel Type in the BASIC tab. This setting selects defaults to optimize performance.
- For application installation, use the “Small” or “Large” setting depending on the tank size and level change rate.
 - For office testing, use the “Test” setting for the quickest response.
- STEP 2:** Press “Write” to confirm your choice. Press “Read” to view new settings.
- STEP 3:** Set the Low Level, High Level, and Range settings. The Range setting should be equal to or a little larger than the Low Level setting to optimize performance. See Figure 3.7 on [page 8](#).
- STEP 4:** Press “Write” to confirm your choice. Press “Read” to view settings.
- STEP 5:** Press the ECHO tab to view the echo waveform graph. The largest echo should be the target. The vertical green line on that echo should mark the distance to the target. Validate the radar is sensing the target correctly. See Figure 3.17 on [page 14](#).
- STEP 6:** In the case of obstructions, use the False Echo Begin and False Echo End settings in the ADVANCED tab to create a false echo mask. See [page 11](#).

UNIT SELECT

The UNIT SELECT tab is located on the left panel below the ECHO tab. The options are:

- Meters (m)
- Feet (ft)
- Inches (in)

BLE NAME

The BLE NAME tab is located on the left panel, below the UNIT SELECT tab. This allows you to change your unit’s Bluetooth name.

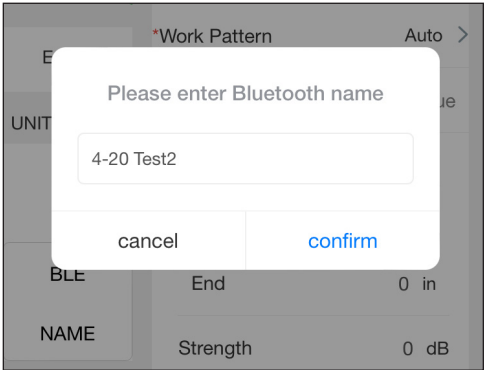


Figure 3.5 Change Bluetooth name

BASIC Tab

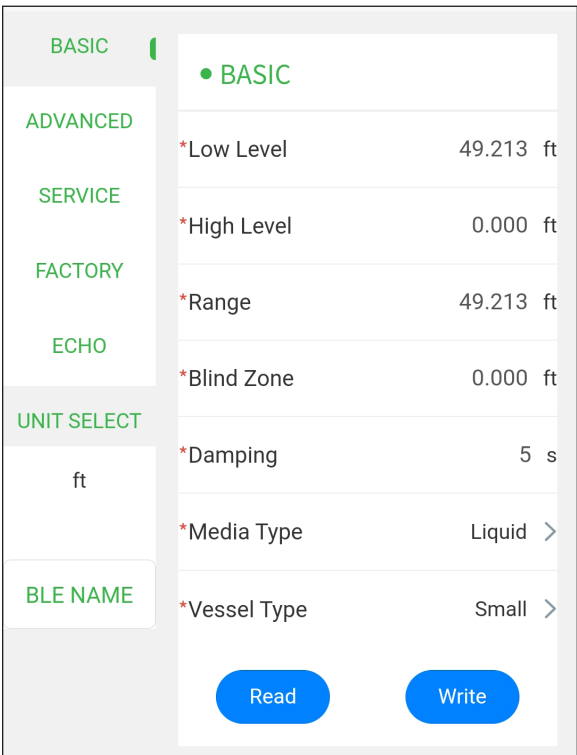


Figure 3.6 BASIC tab settings

Low Level

Low Level is the **furthest** point to be measured from the sensor's reference point. For the 4-20mA sensor, the *Low Level* sets the 4mA setpoint, depending on the Output Mode (see [pg 13](#)). Set the *Low Level* to the lowest point in the tank.

- Range: 0.656 to 49.213 ft (0.2 to 15 m)
- Default: 49.213 ft (15 m)

Low Level must be less than or equal to the sensor range.

High Level

High Level is the **closest** point to be measured from the sensor's reference point. For the 4-20mA sensors, the *High Level* sets the 20mA setpoint, depending on the Output mode. Set the *High Level* value to the max fill point in the tank.

- Range: 0 to 48.88 ft (0 to 14.9 m)
- Default: 0 ft

The *High Level* value must be less than the *Low Level* value.

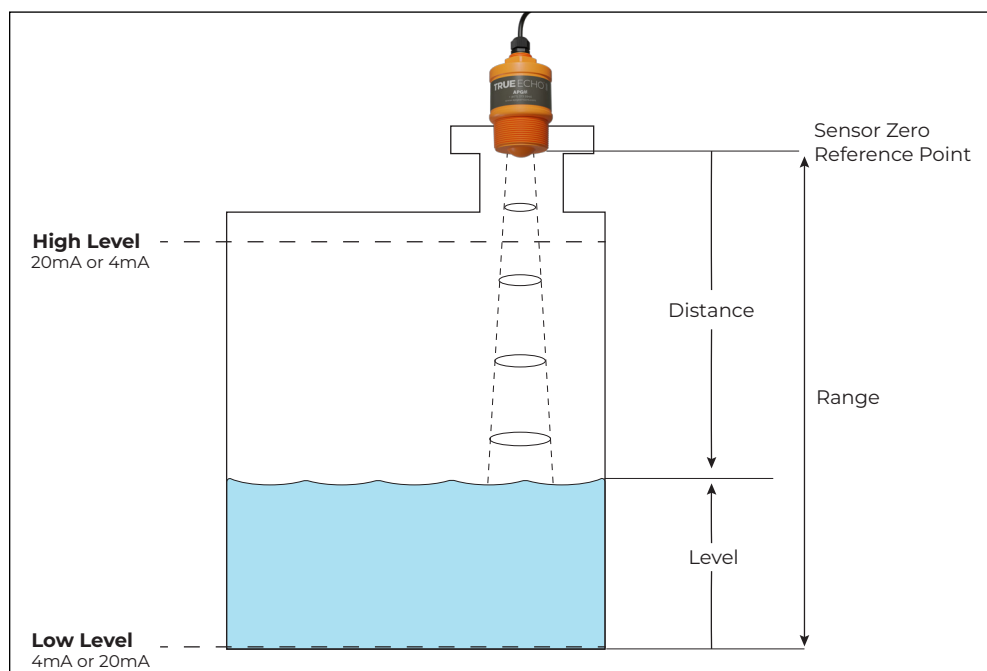


Figure 3.7 High/Low level in a tank

Range

Range defines the maximum distance the sensor will look for a target. Typically, *Range* is set at or a little beyond the desired measuring range to avoid false echoes and achieve a fast and stable measurement.

- Range: 0.656 to 49.213 ft (0.2 to 15 m)
- Default: 49.213 ft (15 m)

Blind Zone

Blind Zone defines the area in front of the sensor that will not be seen as a valid target. Typically, *Blind Zone* is set a little less than the highest level to be measured to achieve a fast and stable measurement.

- Range: 0 to 49.213 ft (0 to 15 m)
- Default: 0.65 ft (0.2 m)

NOTE: The *Blind Zone* and *Range* determine the processing bounds of the application. They should be set to avoid interference and false echoes and to achieve a fast and stable measurement.

Damping

Damping is a filter used to smooth sudden changes in the measurement results. A longer *Damping* time will provide more smoothing for sudden changes. A shorter *Damping* time will provide faster outputs.

Damping values are automatically set by the *Vessel Type* based on expected level change rates. They can also be manually set.

- Range: 0 to 100 seconds
- Default: Set by vessel type

When Damping = 0, the time from power-on to actual level is 7 seconds. After power-on, the time from the level change to new output is given by:

- 1 damping time = 68.4% of final value
- 3 damping time = 97.4% of final value
- 5 damping time = 99.7% of final value

For Example: If the *Damping* time is set to 5 seconds and the position of the measured object changes by a step at time t, the measured output value will change as follows: After the first 5 seconds, 68.4% of the change is completed. After 15 seconds, 97.4% of the change is completed. After 25 seconds, 99.7% of the change is completed.

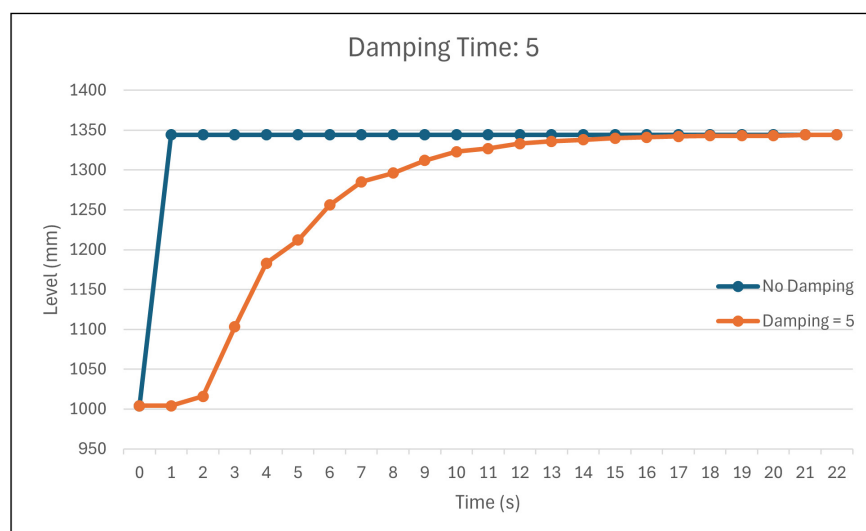


Figure 3.8 RS-485 Damping level over time

Media Type

Media Type affects the selection of the echo algorithm used for Liquids and Solids. The CR-L TRUE ECHO General Purpose Radar's beam angle of 8 degrees is best suited to measure liquids. The options are:

- Liquid (default)
- Solid (not recommended for small particle solids)

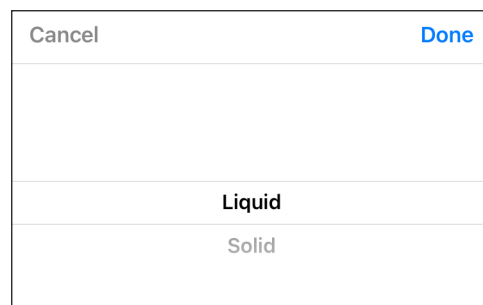


Figure 3.9 Media Type options

Vessel Type

Vessel Type is used to automatically setup damping and other parameters based on how fast the liquid level is expected to change in various tank sizes. The options are:

- Big
- Small (default)
- Fast
- Test

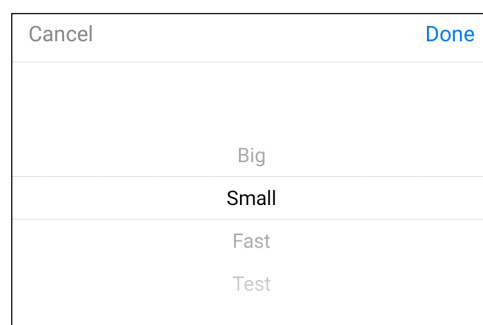


Figure 3.10 Vessel Type options

Selecting the correct Vessel Type is important to properly programming your radar.

For best results, change the *Vessel Type* setting, then immediately press “Write” to confirm. Press “Read” to view the new settings.

Vessel Type Parameter	Vessel Depth	Vessel Width	Level change rate	Application	Default damping time
Big	≥10 m	≥3 m	0.1 m/min	Used when stable reading of a turbulent material is a priority.	10s
Small	1 to 10 m	1 to 3 m	1 m/min	Suitable for most working conditions.	5s
Fast	0.5 to 10 m	0.5 to 3 m	10 m/min	Used when fast measurement is needed.	3s
Test	0 to 15 m	Unlimited	Unlimited	Best for in-house testing.	0s

ADVANCED Tab

False Echo Begin and End

False Echo Begin and *False Echo End* settings are used to manually mask out unwanted false echoes, usually caused by obstacles in the tank. Set the *False Echo Begin* value to before the false echo. Set the *False Echo End* value to after the false echo.

- Range: 0 to 49.213 ft (0 to 15 m)
- Default: 0 (no masks)

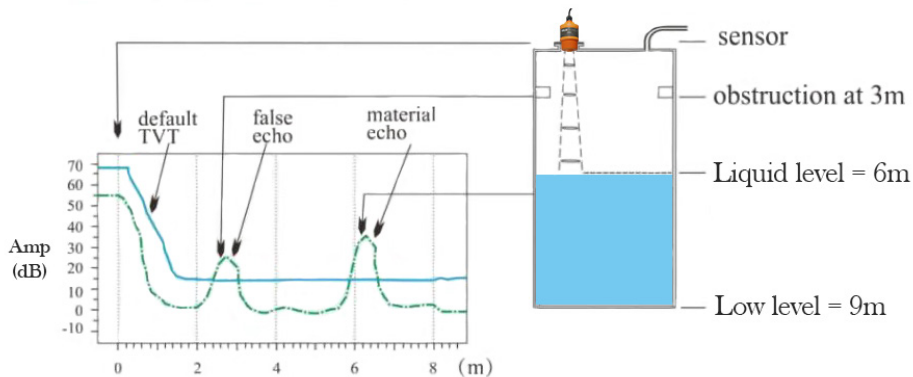
In the example below (Figure 3.11), there is an obstacle at 3 meters. *False Echo Begin* is set to 2 meters and the *False Echo End* is set to 4 meters.

Multiple false echoes masks can be applied. **To delete all masks, enter 0 into both of the *False Echo Begin* and *False Echo End* fields.** Press “Write” to confirm.

BASIC	• ADVANCED
ADVANCED	
SERVICE	*False Echo Begin 0.000 ft
FACTORY	*False Echo End 0.000 ft
ECHO	*False Echo Intensity 18 dB
	*Distance Offset -0.197 ft
UNIT SELECT	
ft	*Bus Address 1
	*Output Mode 4-20mA >
BLE NAME	*4-20mA Current Test 4.0 mA
	*Loss of Echo Output Unchanged >
	Read Write

Figure 3.11 ADVANCED tab settings

Example before False Echo Suppression



Example after False Echo Suppression

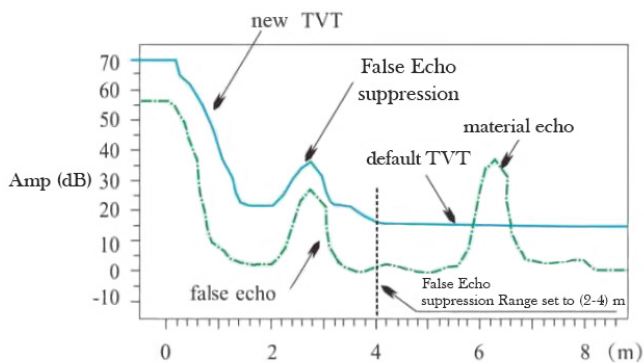


Figure 3.12 False echo suppression

NOTE: TVT means “Time Varying Threshold.” The threshold curve will exclude background noise and mask false echoes.

False Echo Intensity

False Echo Intensity is the intensity of the false echo you want to mask out in decibels (dB). The algorithm adds the value in dB to the obstacle to be masked out. In most cases this setting does not need to be changed.

- Range: 0 to 170 dB
- Default: 18 dB

Distance Offset

Distance Offset positions the zero reference point of the sensor to be at the bottom of the NPT threads as indicated by point **A** in Figure 3.12. It can also be used to offset the sensor reference point as needed.

- Range: -32.808 to 32.808 ft (-10 to 10 m)
- Default: Calibrated at factory

To adjust the reference point to point **B**, enter the distance between points **A** and **B** as a negative value. If **A** is -0.197 and desired reference point **B** is 1 foot in front of the face, enter -1.197 ft.

To adjust the reference point to point **C**, enter the distance between points **A** and **B** as a positive value. If **A** is -0.197 and desired reference point **C** is 1 foot behind the face, enter 0.803 ft.

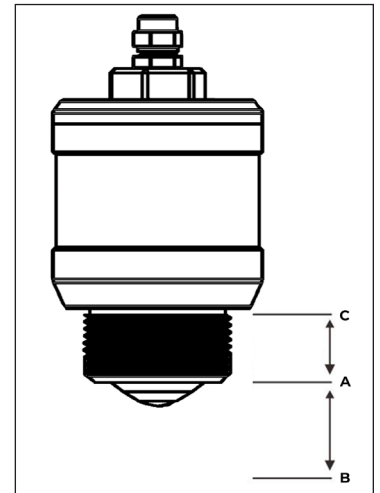


Figure 3.13 Distance Offset

Bus Address

Bus Address can be changed when two or more RS-485 Modbus instruments are connected. The default Bus Address is 1. Address the higher numbered instruments first before adding them to the bus.

See the Modbus Programming section on page 15 for more information about RS-485 programming.

Output Mode

Output Mode changes the output from 4-20mA to 20-4mA. It corresponds to the *Low Level* and *High Level* values as shown in the table below. The options are:

- 4-20mA (Default)
- 20-4mA

<i>Output Mode</i>	Low Level Output	High Level Output
4-20mA	4mA	20mA
20-4mA	20mA	4mA

Cancel Done

4-20mA

20-4mA

Figure 3.14 Output Mode options

4-20mA Current Test

4-20mA Current Test is not currently used for the TRUE ECHO General Purpose Radar.

Loss of Echo Output

Loss of Echo Output allows the user to set the 4-20mA value when the unit encounters a loss of echo error. "Unchanged" holds the value of the last valid echo. The options are:

- Unchanged (Default)
- 22mA
- 3.6mA

Cancel Done

Unchanged

22mA

3.6mA

Figure 3.15 Loss of Echo options

SERVICE and FACTORY Tabs

The SERVICE and FACTORY tabs are primarily used to set parameters by the factory. A password is required to read or write these settings in the app.

For unique applications that require additional radar tuning, please contact APG for help setting up these parameters.

ECHO Tab

The ECHO Tab opens the echo waveform graph with the current distance (D:) and level (L:) measurement. The displayed mA value is only applicable to 4-20mA sensors. The horizontal axis is distance from the sensor face and the vertical axis is the echo strength in decibels (dB).

It may take a few moments for the graph to load.

The graph shows the echo curve (blue line), threshold curve (red line), and current position (green line).

Tap anywhere on the graph to show the threshold and echo curve pinpoint box. This can be used to determine the location of false echoes for the purpose of masking them out.

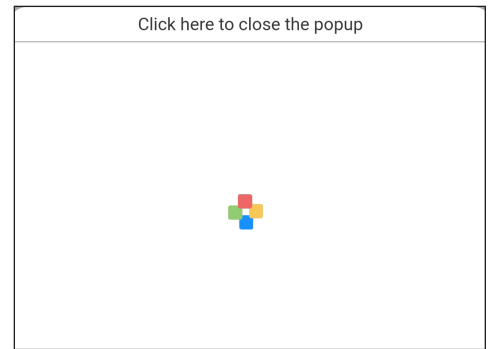


Figure 3.16 ECHO tab loading

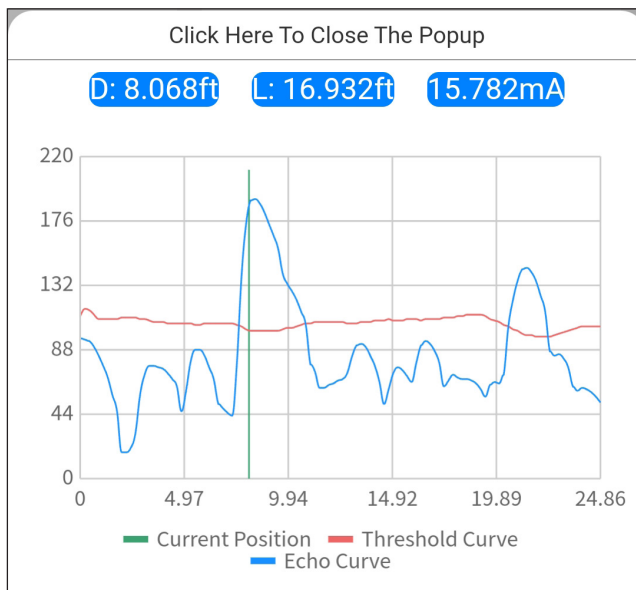


Figure 3.17 Echo curve graph

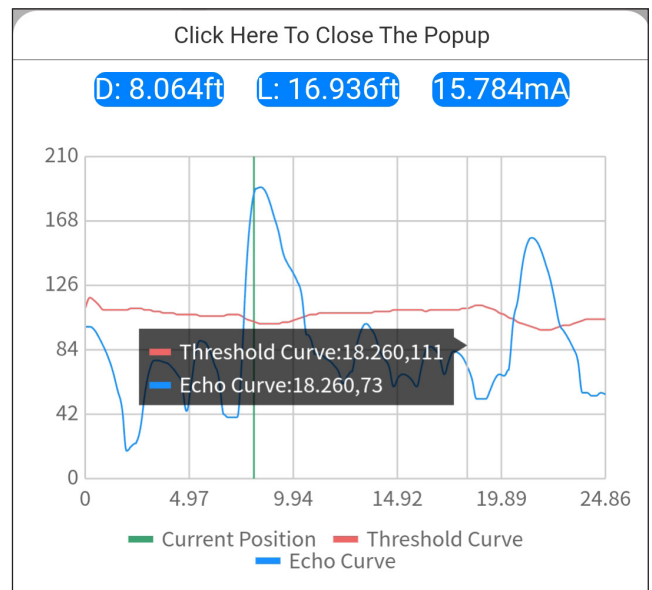


Figure 3.18 Threshold and echo curve pinpoint box

TIP: Tap the top of the popup banner to close the popup.
Do not press the back arrow on your device.

CHAPTER 4: MODBUS PROGRAMMING

RS-485 (4-Wire) Units Only

TRUE ECHO Radar sensors use standard RS-485 Modbus RTU protocol. The sensors can only operate as server devices. Sensor default transmission settings are 9600 Baud, 8 Bits, 1 Stop Bit, No Parity, and require a minimum delay of 100 ms between transactions.

For explanations about specific settings, go to Chapter 3: Programming with the App.

Modbus communication may override Bluetooth communication. Using both simultaneously may result in slower app response times.

Read Registers 4x (Function Code 03)

Modbus Register	Function
0000	Distance (mm)
0002	Level (mm)

Read/Write Holding Registers 4x (Function Code 03)

Modbus Register	Data Type	Function	Value Range
8192	Long CDAB	Low Level	200 to 15000 mm
8194	Long CDAB	High Level	0 to 14900 mm
8196	Long CDAB	Range Setting	200 to 15000 mm
8198	Long CDAB	Blind Zone	0 to 15000 mm
8200	uint16	Damping	0 to 100 seconds
8201	uint16	Media Type	0 = Liquid, 1 = Solid
8202	uint16	Vessel Type	0 = Large, 1 = Small, 2 = Fast, 3 = Test
8203	Long CDAB	False Echo Start	0 to 15000 mm
8205	Long CDAB	False Echo End	0 to 15000 mm
8207	Long CDAB	False Echo Intensity	0 to 170 dB
8209	Signed	Distance Offset	-10000 to 10000 mm
8210	uint16	Bus address	1 to 127
8211	uint16	Output Mode	0 = 4-20mA, 1 = 20-4mA
8212	uint16	4-20mA Current Test	4000 to 20000 uA
8213	uint16	Loss of Echo	0 = unchanged, 1 = 22mA, 2 = 3.6mA

CHAPTER 5: APPLICATION EXAMPLES

Water Tank Level Management (4-20mA Output)

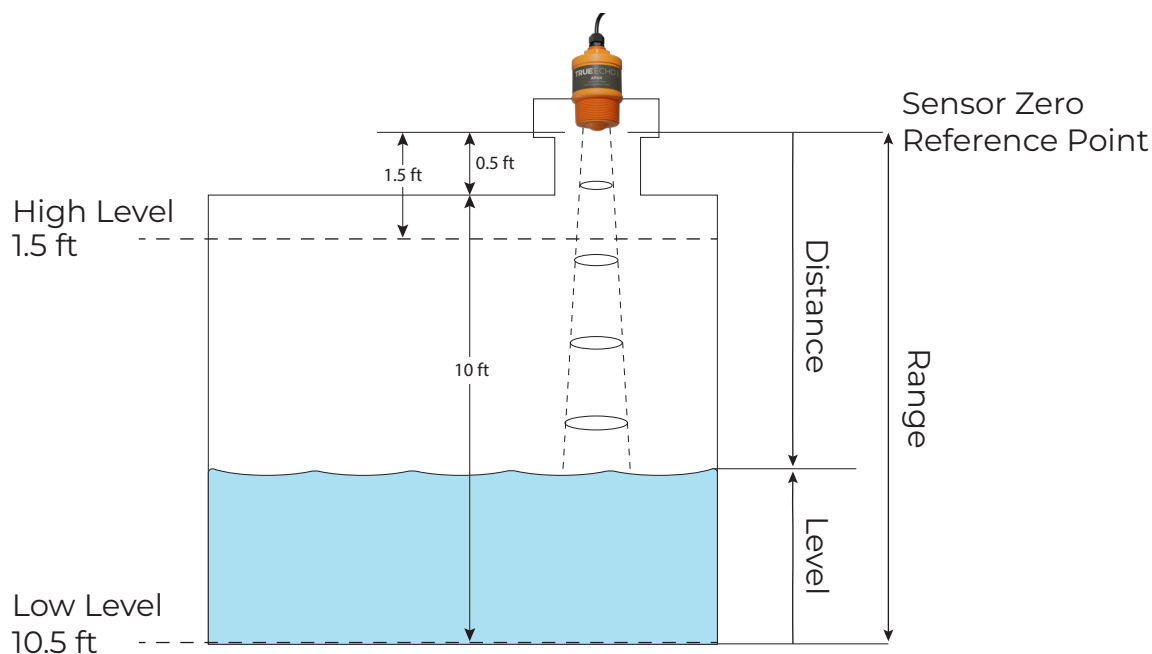


Figure 5.1 Water tank example

Setting	Value	Details
Basic		
Low Level	10.5 ft	Sensor Zero Ref to desired lowest measured point
High Level	1.5 ft	Sensor Zero Ref to desired highest measured point
Range	10.75 ft	Low Level, plus a little
Blind Zone	1.25 ft	High Level, minus a little
Damping	5 s	Default Value (increase if ripples cause spikes)
Media Type	Liquid	Default Value
Vessel Type	Small	Default Value (suitable for most working conditions)
Advanced		
False Echo Begin	0 ft	Default Value; no obstacles to mask out
False Echo End	0 ft	Default Value; no obstacles to mask out
False Echo Intensity	18 dB	Default Value
Distance Offset	-0.197 ft	Default Value; zero reference is on flat surface
Bus Address	1	Default Value; not applicable for 4-20mA output
Output Mode	4-20mA	4mA at Low Level, 20 mA at High Level
mA Current	4mA	Not Applicable
Echo Loss Fault	Unchanged	Holds the last value if loss of echo occurs

Water Tank Level Management (RS485 Output)

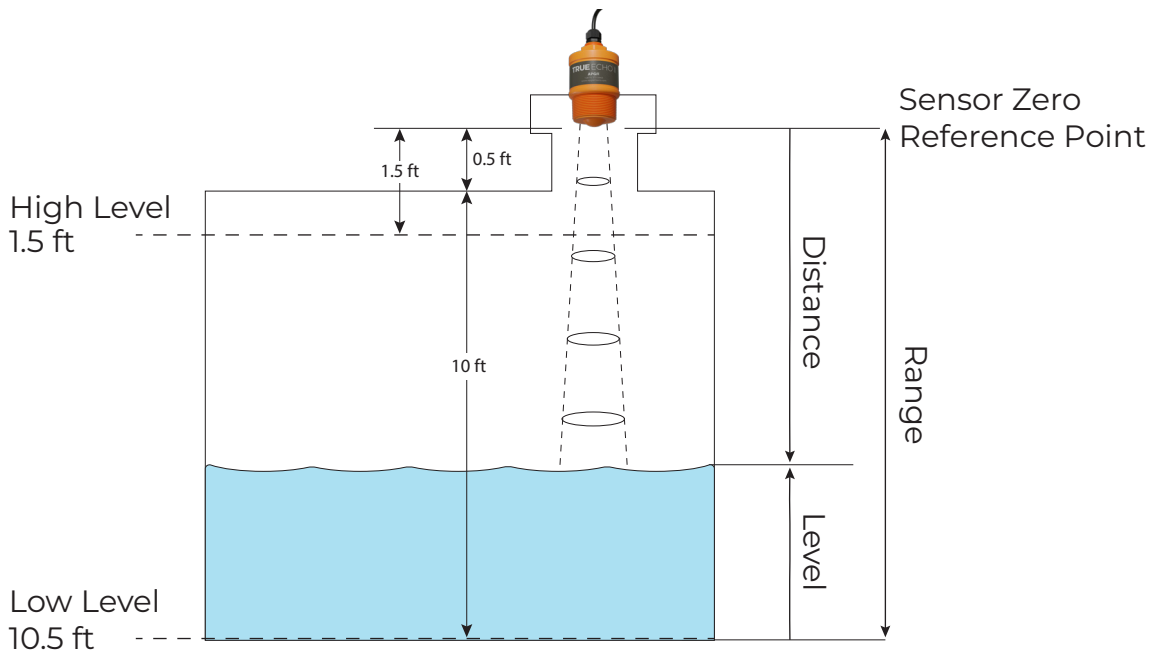


Figure 5.2 Water tank example

Setting	Value	Details
Basic		
Low Level	10.5 ft	Sensor Zero Ref to desired lowest measured point
High Level	1.5 ft	Sensor Zero Ref to desired highest measured point
Range	10.75 ft	Low Level, plus a little
Blind Zone	1.25 ft	High Level, minus a little
Damping	5 s	Default Value (increase if ripples cause spikes)
Media Type	Liquid	Default Value
Vessel Type	Small	Default Value (suitable for most working conditions)
Advanced		
False Echo Begin	0 ft	Default Value; no obstacles to mask out
False Echo End	0 ft	Default Value; no obstacles to mask out
False Echo Intensity	18 dB	Default Value
Distance Offset	-0.197 ft	Default Value; zero reference is on flat surface
Bus Address	1	Default Value; change address as needed
Output Mode	4-20mA	Not Applicable
mA Current	4mA	Not Applicable
Echo Loss Fault	Unchanged	Not Applicable

Flowing Water Level Management (4-20mA Output)

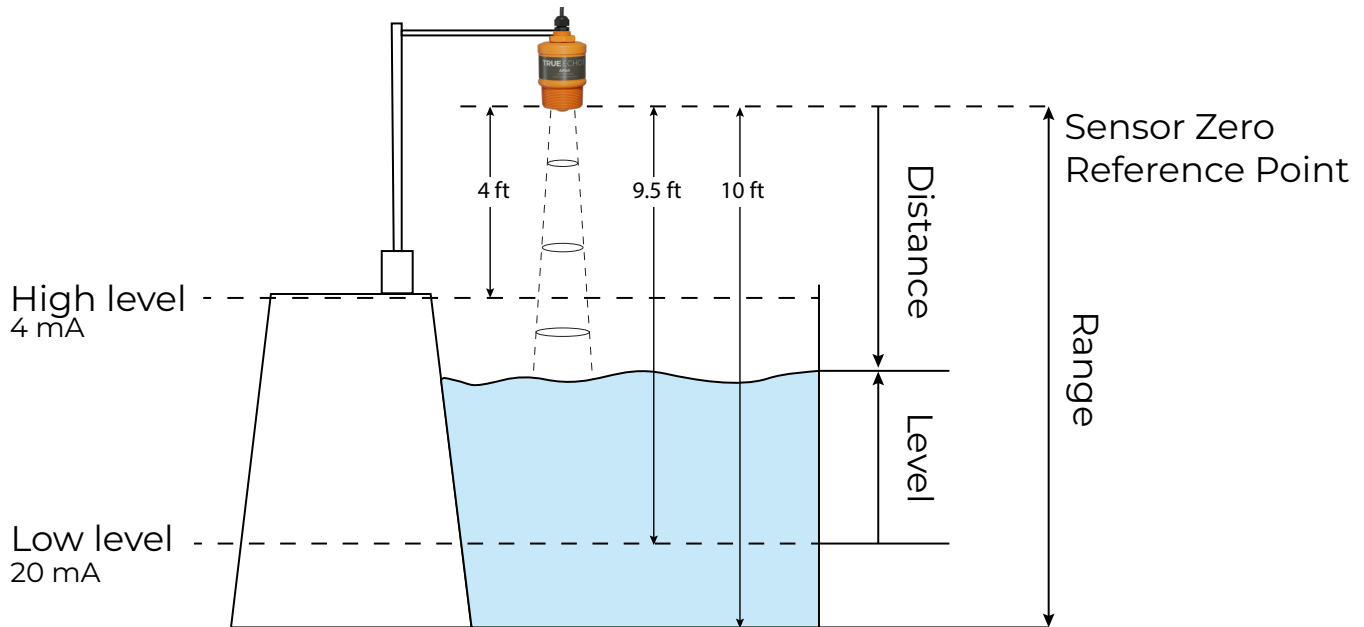


Figure 5.3 Flowing water example

Setting	Value	Details
Basic		
Low Level	9.5 ft	Sensor Zero Ref to desired lowest measured point
High Level	4 ft	Sensor Zero Ref to desired highest measured point
Range	9.75 ft	Low Level, plus a little
Blind Zone	3.75 ft	High Level, minus a little
Damping	5 s	Default Value (increase if ripples cause spikes)
Media Type	Liquid	Default Value
Vessel Type	Small	Default Value (suitable for most working conditions)
Advanced		
False Echo Begin	0 ft	Default Value; no obstacles to mask out
False Echo End	0 ft	Default Value; no obstacles to mask out
False Echo Intensity	18 dB	Default Value
Distance Offset	-0.197 ft	Default Value; zero reference is on flat surface
Bus Address	1	Default Value; not applicable for 4-20mA output
Output Mode	20-4mA	4mA at Low Level, 20 mA at High Level
mA Current	4mA	Not Applicable
Echo Loss Fault	Unchanged	Holds the last value if loss of echo occurs

CHAPTER 6: MAINTENANCE

General Care

Your radar is very low maintenance and will need little care as long as it is installed correctly. However, in general, you should:

- Avoid applications for which the sensor was not designed, such as extreme temperatures, contact with incompatible corrosive chemicals, or other damaging environments.
- Inspect the threads whenever you remove the sensor from duty or change its location.

APPENDIX 1: SETTING DEFAULTS

Setting	Default value
BASIC	
Low Level	49.213 ft (15 m)
High Level	0
Range	49.213 ft (15 m)
Blind Zone	0.656 ft (0.2 m)
Damping	5 s
Media type	Liquid
Vessel type	Small
ADVANCED	
False Echo Begin	0
False Echo End	0
False Echo Intensity	18 dB
Distance offset	-0.197 ft (-0.06 m)
Bus Address	1
Output Mode	4-20mA
4-20mA Current Test	4.0mA
Loss of Echo Output	Unchanged

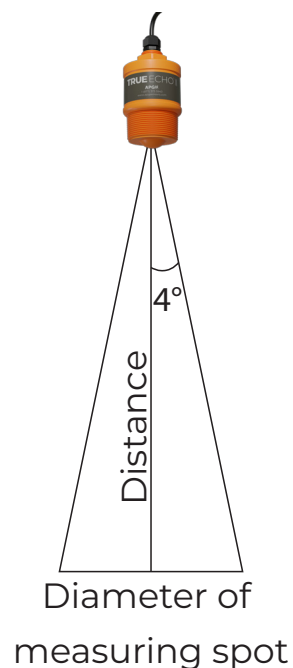
APPENDIX 2: BEAM ANGLE REFERENCE TABLE

The CR-L General Purpose Radar has a 4° half angle beam. The diameter of the measuring spot can be calculated using:

$$\text{Distance} * \tan(4) * 2$$

Distance (ft)	Diameter of measuring spot (ft)
1	0.140
2	0.280
4	0.559
6	0.839
8	1.119
10	1.399
12	1.678
14	1.958
16	2.238
18	2.517
20	2.797
22	3.077
24	3.356
26	3.636
28	3.916
30	4.196
32	4.475
34	4.755
36	5.035
38	5.314
40	5.594
42	5.874
44	6.154
46	6.433
48	6.713
49.213	6.883

Distance (m)	Diameter of measuring spot (m)
1	0.140
2	0.280
3	0.420
4	0.559
5	0.699
6	0.839
7	0.979
8	1.119
9	1.259
10	1.399
11	1.538
12	1.678
13	1.818
14	1.958
15	2.098





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