User Manual

TLV Sensor

Tank Level Vision Sensor

Flatrock Systems TLV Sensor User Manual

Tank Level Vision (TLV) Sensor

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1 Introduction

1.1 Purpose of this Document

This manual describes how to mechanically mount, electrically connect, configure, and commission the Flatrock Systems TLV (Tank Level Vision) Sensor when integrating it into a larger system. It is written for the integration engineer and assumes familiarity with industrial wiring practices, analogue process signals, and basic use of a Windows configuration application.

Read Chapter 2, “Safety,” before wiring or powering the sensor. Keep this document accessible to all personnel who install, configure, or service the unit.

1.2 Audience and Scope

The scope of this manual is limited to integration of the TLV Sensor as a component. It does not cover the design of the host system, the process vessel, or the controller that consumes the sensor output. Where a parameter depends on the host installation, this manual states the requirement the host must meet rather than prescribing a design.

1.3 Additional Documentation

It is the responsibility of the integrator to comply with all local, regional, and national regulations governing the installed system, including those for electrical safety, hazardous locations (where applicable), and environmental protection. Confirm that every connected device meets the essential requirements of the applicable directives and bears the appropriate conformity marking.

2 Safety

2.1 Intended and Unintended Use

The TLV Sensor is intended for non-contact level and distance measurement in industrial equipment, where it reports a measured distance as a standard analogue process signal. It must be installed, powered, and operated within the limits given in Section 3.2, “Specifications.”

Any use outside these limits — including operation outside the rated supply, environmental, or load conditions, or use as a safety-rated or fail-safe sensing element — is considered unintended use. The TLV Sensor is not a safety device and must not be the sole means of preventing an overfill, collision, or other hazardous condition.

2.2 Limitation of Liability

The information in this manual reflects applicable standards, the current state of technology, and Flatrock Systems’ knowledge and experience. Flatrock Systems assumes no liability for damage resulting from:

- Failure to follow this manual
- Incorrect or unintended use
- Installation or service by untrained personnel
- Unauthorised modification of the unit
- Operation outside the specified electrical, mechanical, or environmental conditions

2.3 Fundamental Safety Notes

CAUTION!
De-energise the supply before connecting or disconnecting the sensor. Verify polarity and supply level before applying power. Reverse polarity or over-voltage may damage the unit.

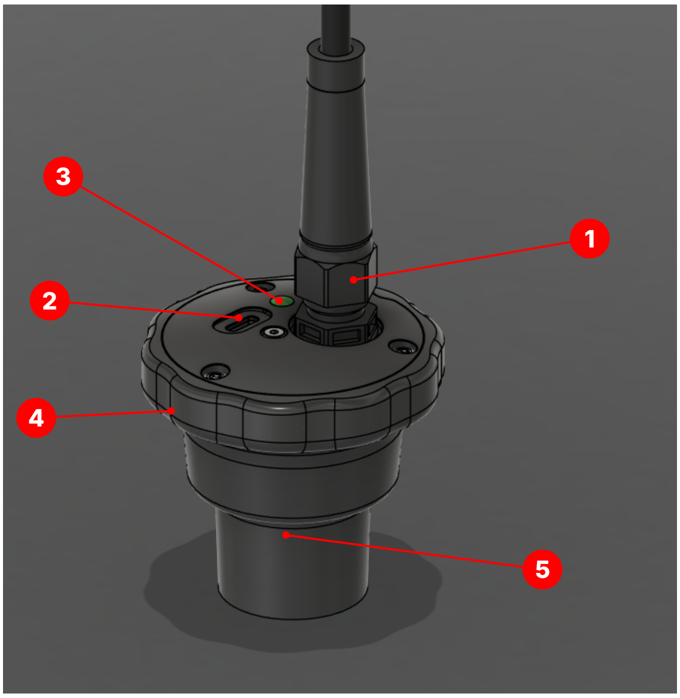
CAUTION!
The unit contains static-sensitive electronics. Observe ESD precautions whenever the enclosure is open.

CAUTION!
The sensor measures distance optically through a window on its sensing face, using an invisible infrared (940 nm) laser that is eye-safe under normal use (Class 1 per IEC 60825-1). As with any optical source, do not stare directly into the window at close range for extended periods, and do not view it with magnifying optics. Keep the window clean and unobstructed; do not apply solvents or abrasives not listed in Section 11.

Follow the valid environmental and electrical-safety regulations in the country of use and at the installation site.

3 Product Description

The Flatrock Systems Tank Level Vision (TLV) Sensor is a compact, non-contact level and distance sensor for tanks and vessels. It mounts through a threaded process connection on the top of the vessel, looks down at the liquid (or other target) surface, and reports the measured distance as a standard analogue process signal. The user-facing interfaces — the USB configuration port and status LED — and the cable gland are on the top face; the optical sensing window is on the underside, inside the process thread.



1	Cable gland / strain relief
2	USB-C configuration port
3	Status LED
4	Grip ring (cap)
5	1 in NPT process connection
6	Optical sensing window (underside; see Fig. 4)

Figure 1: TLV Sensor external features

3.1 Model Designation and Ordering Information

Each TLV Sensor is identified by a part number that encodes its build configuration as a sequence of fields:

`TLV - S - N1 - BK - 1B`

The example above decodes as a **S**tandard sensor with a **1** inch **N**PT process connection, a **B**lac**K** enclosure, and a **1** m **B**are-end cable. The fields and the currently available option codes are:

Field	**Position**	**Code**	**Description**
Product family	1	TLV	Tank Level Vision Sensor
Variant	2	S P	Standard *Plus — integrated display (future)*
Process connection	3	N1 *(future)*	1 in NPT *Additional NPT sizes and flange mounts (future)*
Enclosure	4	BK CL	Black (polycarbonate) Clear (polycarbonate)
Cable & termination	5	1B 2B	1 m cable, bare end 2 m cable, bare end

Ordering information (continued)

Field	Position	Code	Description
		`1C`	1 m cable, custom connector
		`2C`	2 m cable, custom connector

Note to maintainers: codes shown in italics are planned variants and are not yet orderable. As new variants are released — the Plus (P) display model, additional process connections, and flange mounts — add their option codes above and extend the currently-available list below.

Currently available configurations. All combinations of the currently shipping options are orderable (8 configurations total):

Part number	Configuration
`TLV-S-N1-BK-1B`	Black, 1 m bare end
`TLV-S-N1-BK-2B`	Black, 2 m bare end
`TLV-S-N1-BK-1C`	Black, 1 m custom connector
`TLV-S-N1-BK-2C`	Black, 2 m custom connector
`TLV-S-N1-CL-1B`	Clear, 1 m bare end
`TLV-S-N1-CL-2B`	Clear, 2 m bare end
`TLV-S-N1-CL-1C`	Clear, 1 m custom connector
`TLV-S-N1-CL-2C`	Clear, 2 m custom connector

3.2 Specifications

The following data describe the TLV Sensor. Unless otherwise stated, values apply at 24 V DC supply and 25 °C ambient.

Parameter	Value	Conditions / Notes
General		
Product	TLV Sensor	Non-contact level / distance sensor
Years of manufacture	From 2026	
Measurement		
Measurement principle	Non-contact optical, direct time-of-flight (multi-zone)	
Measurement range	0.02 m to 4 m	Usable range depends on target reflectance and ambient light
Resolution	1 mm	
Ranging accuracy	±15 mm	Typical; reflectance-, distance-, and ambient-dependent
Update rate	10 Hz	Nominal
Signal conditioning	Outlier rejection + adaptive (Kalman) filtering	On-board; yields one stable distance value per update
Optical		
Effective field of view	Approx. 11° (16° diagonal)	Central measurement zones only; see note below
Illumination source	Invisible infrared, 940 nm	
Laser safety	Class 1	Per IEC 60825-1
Optical window	Polyetherimide (PEI)	
Analogue Output		
Output types	4 mA to 20 mA, 0 mA to 20 mA, 0 V to 5 V, 0 V to 10 V	User-selectable
Output resolution	16-bit (65 536 steps)	

Specifications (continued)

Parameter	Value	Conditions / Notes
Transfer function	Linear; `DMIN`–`DMAX` mapped across the output span	Clamped beyond endpoints; invertible (`DMIN` > `DMAX`)
Default output mode	4 mA to 20 mA	Factory default
Default mapping	`DMIN`=100 mm, `DMAX`=2000 mm	Factory default
Output calibration	Two-point (zero + gain) per output family	Stored in non-volatile memory
Current-loop drive	Max. loop resistance 320 Ω at 20 mA	4 mA to 20 mA / 0 mA to 20 mA modes
Voltage-mode load	High-impedance receiver; min. load 1000 Ω	0 V to 5 V / 0 V to 10 V modes
Power Supply		
Supply voltage (nominal)	24 V DC	
Operating input range	18 V to 36 V DC	Full performance across range
Absolute maximum input	36 V	Do not exceed
Supply current	≈ 100 mA	At 24 V
Input protection	Transient (TVS)	Observe polarity; reverse polarity or over-voltage may damage the unit
Surge immunity	Designed to IEC 61000-4-5	Not tested or verified to the standard
Configuration & Data Logging		
Configuration interface	USB virtual COM port (CDC)	115 200 baud, 8-N-1
Configuration tool	Flatrock Systems TLV Configurator (Windows)	See Section 7
Command protocol	ASCII line commands	`OK` / `ERR` responses
Configuration window	Host must enumerate within ≈ 60 s of power-up	Otherwise the unit enters data-logging mode
Data logging	CSV to USB mass-storage drive	Recorded variables selectable in the app
Live diagnostics	Measurement stream over USB	Same variables as the CSV log
Firmware update	Over USB from the app	See Section 7.13
Settings retention	Non-volatile; restored on power-up	
Mechanical & Materials		
Process connection	1 in NPT	
Output cable	3-conductor, 24 AWG (0.205 mm^2), overall shield, 6.1 mm (0.24 in) OD	igus chainflex; hardwired, no connector supplied
Cable length	1 m or 2 m	Per ordering code (Section 3.1)
Enclosure material	Polycarbonate (PC)	Black (`BK`) or clear (`CL`)
Wetted materials	PEI (window), PC (enclosure)	
Dimensions	65 mm × 65 mm × 61 mm (W × D × H)	Body, excl. cable gland; 126.3 mm overall height incl. strain relief (Section 5.2)
Mass	118 g	Without cable
Environmental		
Operating temperature	−40 °C to 85 °C	
Storage temperature	−40 °C to 85 °C	Non-condensing; store in original packaging
Ingress protection	Not formally rated	Splash-/water-resistant by design; do not submerge (Section 5.5)

Field-of-view note: the optical sensing element images a wider scene, but the TLV Sensor derives its distance reading only from the small group of zones at the centre of that field. The effective measurement cone is therefore approximately 11° across (about 16° on the diagonal). Mount the sensor so this central cone, plus a clearance margin, looks squarely at the target

(Section 5).

4 Functional Overview

4.1 Principle of Operation

The TLV Sensor measures the distance to a target surface using a non-contact optical time-of-flight method over a small field of view. The raw range data is conditioned by on-board signal processing to reject outliers and reduce noise, producing a single stable distance value at the nominal update rate.

That distance is then mapped to the selected analogue output. The integrator defines a near point and a far point (see Section 7); the sensor scales distances between those two points linearly across the full output span, clamping at the endpoints. Distances at or below the near point produce the bottom of the output span and distances at or above the far point produce the top of the span.

4.2 Interfaces at a Glance

- **Analogue output** — the primary process signal, available as a current loop or a voltage output (Section 6).
- **USB configuration** — a virtual COM port driven by the Flatrock Systems TLV Configurator app to set the output mode, the measurement-to-output mapping, the fault behaviour and calibration, to read live values, and to update the sensor's firmware (Section 7).
- **USB data logging** — if no host PC is present at power-up, the USB port can instead host a mass-storage drive and record the selected measurement variables to a CSV file (Section 8).

Configuration settings persist in non-volatile memory and are restored automatically on every power-up.

5 Mechanical Installation

5.1 Mounting

The sensor mounts through its 1 in NPT process connection. Thread it into a matching 1 in NPT fitting on the vessel or bracket, using a suitable thread sealant or PTFE tape, and tighten enough to seat and seal without over-stressing the thread. Mount the sensor so that its sensing face points squarely at the target surface, as close to perpendicular as practical. The mounting must hold the sensor rigidly; vibration or flex that changes the standoff or aim will appear directly in the measured distance.

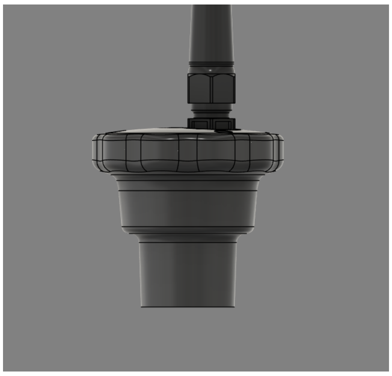


Figure 2: Sensor mounting and orientation

5.2 Dimensions

The TLV Sensor housing measures 65 mm × 65 mm × 61 mm (W × D × H), excluding the cable gland. The overall height, including the cable gland and strain relief, is 126.3 mm. The 1 in NPT process connection provides approximately 21.9 mm of thread engagement. Allow clearance above the sensor for the cable gland, the USB connector, and the cable drip loop (Section 5.5).

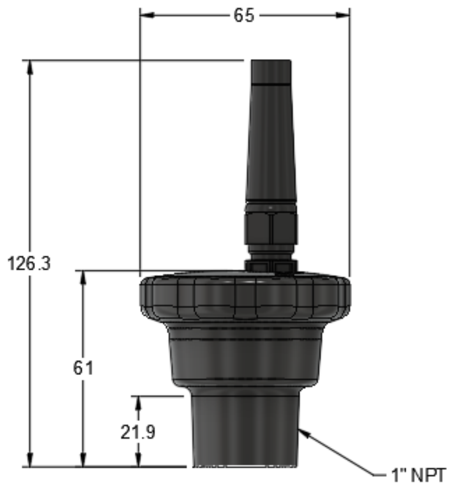


Figure 3: Overall dimensions (mm)

5.3 Field of View and Target

The sensor takes its reading from a narrow central cone of approximately 11° (about 16° on the diagonal); see the field-of-view note in Section 3.2. Keep this cone, plus a clearance margin, clear of fixed obstructions, fittings, and the vessel wall between the sensor and the target; objects inside the cone can be measured instead of the intended surface. As a guide, allow a keep-out radius of at least 0.1 m per metre of standoff (roughly the 11° cone) around the optical axis.

Highly transparent, mirror-like, or strongly angled surfaces return little usable signal and may degrade accuracy. Where the target is foamy, turbulent, or variable, place the sensor for the most consistent presentation of the surface.

5.4 Optical Window

The sensing face is closed by a polyetherimide (PEI) optical window (wetted materials: PEI and polycarbonate, PC). It must remain clean and free of condensation, film, splashes, dust, or deposits: any of these attenuate the optical signal, bias the reading, and degrade performance. For best results, operate the sensor in a clean environment and keep the window dry and unobstructed. Where condensation or product build-up is likely, position the sensor to minimise accumulation on the window and inspect it regularly. See Section 11 for cleaning.

Figure 4: Underside of the sensor showing the optical window within the 1 in NPT process connection

5.5 Environmental Protection

The polycarbonate enclosure is designed to be splash- and water-resistant: it is intended to withstand incidental splashing, spray, and washdown that may occur in normal service. It has *not* been tested or certified to a specific IEC 60529 ingress-protection (IP) code, so no IP rating is claimed.

Accordingly:

- Do not submerge or immerse the sensor, and do not subject it to high-pressure jets or sustained directed spray.
- Mount the sensor with the cable exit oriented to shed water, and provide a drip loop in the cable so liquid runs off rather than tracking along the cable to the entry.
- Keep the optical window and cable entry intact; do not modify or open the enclosure, which would compromise the seal.

6 Electrical Integration

6.1 Field Wiring

The sensor is supplied with a permanently attached 3-conductor cable; **no field connector is provided**. Field connections are made by terminating the three conductors at the host. The cable is igus chainflex, 24 AWG (0.205 mm^2) per conductor, with an overall shield and a 6.1 mm (0.24 in) outer diameter. Confirm conductor identification against the unit marking before wiring.

Conductor	Wire marking	Function
V+ (24 V DC)	1	Supply input
OUTPUT	2	Analogue process output (current or voltage)
GND	Green	Supply and signal return
Shield (drain)	—	Cable shield — terminate per Section 6.4

Table 3: Output cable conductor assignment

6.2 Power Supply

Power the sensor from a nominal 24 V DC supply. The unit operates over an input range of 18 V to 36 V DC; 36 V is also the absolute maximum input (do not exceed). Below the minimum input the analogue output stage loses headroom and the output may become inaccurate, particularly in the 4 mA to 20 mA and 0 V to 10 V modes. Size the supply and wiring for the sensor current (≈ 100 mA at 24 V) plus margin. Protect the supply branch appropriately and observe correct polarity; reverse polarity or over-voltage may damage the unit. The supply input is protected by a transient-voltage-suppression (TVS) device and is designed to meet the surge-immunity requirements of IEC 61000-4-5, although it has not been formally tested or verified to that standard.

6.3 Analogue Output Wiring

The OUTPUT conductor carries either a current-loop signal or a voltage signal depending on the configured mode (Section 7).

- **Current modes** (4 mA to 20 mA, 0 mA to 20 mA): wire the output as a loop returning to GND. Keep the total loop resistance (receiver input plus wiring) within the maximum the output can drive at the rated supply (500 Ω at 20 mA).
- **Voltage modes** (0 V to 5 V, 0 V to 10 V): connect the output to a high-impedance receiver input referenced to GND. The receiver input impedance must be at least 1000 Ω. Keep wiring short to limit drop and noise pickup.

Use the 4 mA to 20 mA mode for the best noise immunity over long runs and for break-detection at the receiver.

6.4 Grounding and Shielding

Terminate the cable shield (drain wire) at the host end, to the host system's chassis or clean earth. For long runs, the 4 mA to 20 mA current-loop modes also give the best noise immunity.

7 Configuration

7.1 The TLV Configurator App

The sensor is configured with the **Flatrock Systems TLV Configurator**, a Windows application supplied with the product. It sets the output mode, defines the measurement-to-output mapping, reads live values, chooses what the sensor logs, and updates the sensor's firmware. No driver installation is required: the sensor enumerates as a standard USB virtual COM port (CDC).

Download the latest version of the app from `flatrocksystems.dev/downloads` and run the `-setup.exe` installer on the host PC. The app checks for its own updates on launch; when a newer version is published it offers **Update & restart** in a banner below the connection bar, and installs it without a manual download.

The app presents three tabs in normal use:

- **Configuration** — the everyday workflow: read the stored settings, set the output mode, distance limits, calibration offset, error output, status LED, and log variables, and watch the live distance.
- **Terminal** — a console showing everything the sensor reports, with buttons for the diagnostic actions support may ask you to run.
- **Firmware** — compares the sensor's firmware against the latest published release and updates it over USB.

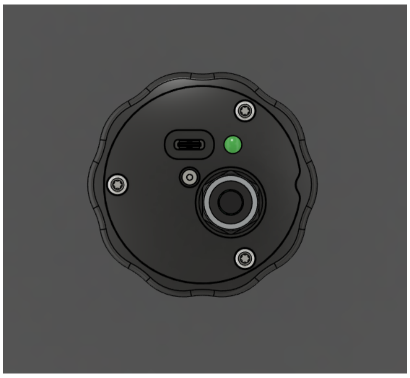
Three further tabs (**Voltage Cal**, **Current Cal** and **ST-Link Flash**) are reserved for factory and service work and appear only in Advanced Mode (Section 7.15).

The title bar also carries a **Sign in** control for config profiles (Section 7.12), the **Advanced mode** button, a dark/light theme switch, and the installed app version.

Every setting changed through the app is written to the sensor's non-volatile memory and restored automatically on the next power-up.

7.2 Connecting to the Sensor

The USB-C configuration port and the status LED are on the top face of the sensor, next to the cable gland (Figure 5).



1	USB-C configuration port
2	Status LED
3	Cable gland / strain relief

Figure 5: Top-face interfaces

1. With the sensor unpowered, connect its USB port to the host PC.
2. Apply power to the sensor.
3. Launch the TLV Configurator. In the **Port** list, the sensor is auto-detected and shown at the top, starred, as "`⋆ TLV Sensor (COMn)`". If it is not listed, click **Refresh**.
4. Click **Connect**. The status indicator turns green and shows the connected port. The link runs at 115 200 baud (8-N-1).

On connect the app reads the sensor's stored configuration automatically and fills the form with it, so the **Configuration** tab always opens on the sensor's real settings. A pill at the right of the connection bar reports whether the installed firmware matches the latest published release; clicking it opens the **Firmware** tab (Section 7.13).

> *Note: the USB port serves a configuration host only while a PC is connected shortly after power-up. If no PC enumerates within about a minute of power-up, the port switches to data-logging mode (Section 8). Connect the PC and open the app promptly after powering the sensor to configure it.*

7.3 Reading and Writing the Configuration

The **Device Config** panel at the top left of the **Configuration** tab shows what is actually stored on the sensor. It is filled automatically on connect; **Read Config** re-reads it at any time.

The cards below it are a form. Editing them changes nothing on the sensor until you click **Send Configuration**, which writes every setting in one go and then re-reads the sensor to confirm. Any value in the panel that differs from the form is highlighted, so unsent edits are visible before you commit them.

7.4 Sensor Name

Under **Sensor Name**, give the unit a label of up to 31 characters (e.g. `Tank 1 Level`). The name identifies the sensor in the app and is stamped into the header of every log file it writes, which is what tells two units' logs apart.

7.5 Selecting the Output Mode

In the **Output Mode** group, choose the analogue output type your receiver expects — `4-20mA`, `0-20mA`, `0-5V`, or `0-10V`. The sensor keeps an independent calibration for the current and voltage families, so the output stays calibrated when you switch modes. The selected mode is stored and restored on power-up.

7.6 Mapping Distance to Output

Under **Distance Limits (mm)**, set the distance window that the output span is mapped onto:

- **DMIN** (0% output) — the distance, in millimetres, that produces the bottom of the output span (e.g. 4 mA in `4-20mA` mode, or 0 V in `0-10V` mode).
- **DMAX** (100% output) — the distance, in millimetres, that produces the top of the output span (e.g. 20 mA or 10 V).

Distances between `DMIN` and `DMAX` scale linearly across the full span and are clamped at the endpoints. To invert the mapping — so that a *shorter* distance gives a *higher* output — set `DMIN` greater than `DMAX`. If `DMIN` equals `DMAX` the output is held at its minimum.

7.7 Calibration Offset

Calibration Offset adds a fixed correction, in millimetres, to every reading before it is mapped to the output. Use it when a unit reads consistently high or low — for example because it sits recessed in a fitting. If the sensor reports 990 mm against a known 1000 mm target, enter `10`; negative values subtract. Accepted range is $\pm$10 000 mm.

Because the correction shifts the reading itself, `DMIN` and `DMAX` keep their real-world meaning. With polling running, the card previews the corrected reading against the live measurement so the value can be dialled in against a known target. The offset is specific to one installed unit and is never copied by a config profile.

7.8 Error Output

Error Output selects what the analogue output does if the sensor can no longer measure reliably, so downstream equipment can detect the fault rather than read a stale level:

- **DMIN** — drive to the bottom of the output span.
- **DMAX** — drive to the top of the output span.
- **ZERO** — switch the output off, giving roughly 0 mA. Available in `4-20mA` mode only, where 0 mA is outside the valid signal band and so is distinguishable from a legitimate low reading — something 4 mA cannot be. The app offers this option only when the form's output mode is `4-20mA`.

  A briefly lost target is not a fault: the sensor holds the last good level, so that agitation, foam, or a passing obstruction does not move the output. If the target stays lost for more than 60 s, the hold itself is treated as a fault and the output goes to the selected rail — a blinded sensor cannot keep reporting an old level indefinitely, which downstream would be indistinguishable from a steady tank.

7.9 Status LED

Status LED enables or disables the steady green "healthy" indicator on the top face — useful where the light would be a distraction. Fault codes are still shown when it is off (Section 10.1).

7.10 Log Variables

Log Variables chooses which measurement variables the sensor records. One selection governs both the CSV file written to a USB drive (Section 8) and the live diagnostic stream shown in the **Terminal** tab, so a captured stream always matches the file.

Tick the variables to record:

- **Filtered distance** — the conditioned reading that drives the analogue output. **Gated zone median** is the same level before time filtering, so logging both shows how much smoothing is being applied.
- **Raw distance**, **Target status**, **Range sigma** and **Signal per SPAD** — the per-zone detail behind that reading.
- **Zone gate verdict**, **Good zone count** and **Bad sample counter** — which zones the sensor trusted and how many.
- **Sensor temperature** — the optical sensor's internal temperature.

The four per-zone variables are marked $\times$ `16 zones`: each adds one column per measurement zone, so they account for 64 of the 71 columns in a full row. The zone gate verdict reports on all 16 zones in a single column. The card shows the resulting column count as you tick, and **All** / **None** set every variable at once. A timestamp is always recorded as the row index and cannot be switched off.

Recording everything is the factory default and is right for commissioning or a fault investigation. For long unattended captures, turning off the per-zone variables takes a row from 71 columns to 7, which keeps the file small and readable without losing the level history.

> *This setting trims the log, not the measurement: the sensor always computes the full result, and the analogue output is unaffected by what is recorded.*

7.11 Verifying the Live Reading

In the **Live Distance** panel, click **Read Once** for a single measurement, or **Start Polling** to update the reading continuously (about twice per second). A trace of recent readings and a bar showing the position within the `DMIN–DMAX` window are drawn alongside, and the **Output Signal** panel above reports the voltage or current the sensor should be driving for that reading. Confirm that the displayed distance tracks the target and that the analogue output measured at the receiver agrees.

7.12 Config Profiles

A config profile stores a sensor's settings under your account so the same setup can be applied to other units — useful when commissioning several identical installations.

Click **Sign in** in the title bar and sign in with an email address and password or with a Google account. Then, on the **Config Profiles** card, use **Save as Profile...** to store the current form as a named profile, optionally including the sensor name. **Apply** writes a saved profile to the connected sensor after showing what it will change; **Delete** removes it.

A profile carries the output mode, distance limits, error output, status LED, and log variable selection. It never carries the per-unit calibration — neither the analogue calibration values nor the calibration offset — because those describe one physical unit and copying them would bias another sensor. Profiles are cached locally, so they can be saved and applied while offline and sync when the PC is next connected.

7.13 Firmware Updates

The **Firmware** tab lists the sensor's installed firmware and bootloader versions against the latest published release, and marks each as up to date or updatable. **Fetch firmware** downloads the current release and verifies its checksum; **Flash Firmware** then installs it over the USB connection, showing progress and a log. The app reconnects to the sensor automatically when the update completes. A local `.bin` file can be selected instead with **Choose .bin File...**.

> *Keep the sensor connected and powered for the whole update. Firmware updates preserve the stored configuration and calibration. Updating the* bootloader *is a service operation performed over ST-Link (Section 7.15), not over USB.*

7.14 Terminal and Diagnostics

The **Terminal** tab shows every line the sensor reports. Three buttons cover the actions support may ask for:

- **Dump Errors** — prints the sensor's stored fault log: a count of every fault code it has ever recorded, plus the most recent fault transitions. The log survives power cycles and firmware updates, so it shows intermittent faults that are not present at the time of the call.
- **Debug On** / **Debug Off** — streams live measurement rows, in the same format and with the same variables as the CSV log (Section 7.10). Useful for watching per-zone behaviour while aiming a sensor. It is not retained: the stream is always off after a power cycle.

Clear empties the console display; it does not affect the sensor.

7.15 Advanced Mode

Advanced mode in the title bar is passcode-protected and reserved for factory and service work. It reveals the **Voltage Cal** and **Current Cal** tabs, which trim the analogue output against a reference meter and write the per-unit calibration values; the **ST-Link Flash** tab, which programs a bare board over SWD with a bootloader, application, and integrity metadata; a free-form command entry in the **Terminal** tab; the analogue calibration values in the **Device Config** panel; and the option to fetch release-candidate firmware instead of the public release.

> *Analogue calibration is performed at the factory. Re-running it with an inadequate reference will degrade output accuracy.*

8 Data Logging

The sensor can record measurements to a removable USB mass-storage drive for field diagnostics. If no configuration host enumerates within about a minute of power-up, the USB port switches to host mode; insert a formatted drive and the sensor appends measurement records to `TOF_DATA.CSV` on it. To watch the same data at a PC instead, use **Debug On** in the app's **Terminal** tab (Section 7.14).

Records are written about ten times per second and flushed in small batches, so a sudden loss of power or removal of the drive costs at most the last few seconds of data. Remove the drive only when the sensor is idle.

Which variables each row carries is set in the app under **Log Variables** (Section 7.10). The file is self-describing, so it can be read without knowing how the sensor was configured: three comment lines record the sensor name, the variable selection, and the measurement zones behind the per-zone columns, followed by a column-name row and then one row per measurement.

> *A log file's columns are fixed when the file is created. If the variable selection is changed and the same drive is re-inserted, the sensor renames the existing* `TOF_DATA.CSV` *to* `TOF_DA01.CSV` *(then* `TOF_DA02.CSV`*, and so on) and starts a new file, so no file ever contains rows of two different shapes. Delete old logs from the drive periodically.*

The sensor also writes `ERRORS.CSV` on each insertion — a snapshot of the stored fault log, the same information **Dump Errors** reports over USB.

> *To return to configuration mode, reconnect a host PC and re-power the sensor.*

9 Commissioning

1. **Mount the sensor.** Thread it into its 1 in NPT fitting, rigid and square to the target, with the measurement cone clear (Section 5).
2. **Terminate the output cable.** Connect V+, OUTPUT, GND, and the shield per Section 6. Confirm polarity before applying power.
3. **Connect a configuration host.** With the sensor unpowered, connect the USB port to a PC, apply power, then launch the TLV Configurator and click **Connect** (Section 7).
4. **Set up the sensor.** On the **Configuration** tab, choose the output type your receiver expects, enter **DMIN** and **DMAX** for the near and far distances of your application, and set the **Error Output** your control system expects on a fault. Name the sensor if it is one of several.
5. **Write it to the sensor.** Click **Send Configuration**, and check that the **Device Config** panel reads back what you intended.
6. **Verify the live reading.** Use **Read Once** / **Start Polling** and confirm the output at the receiver tracks the target across the window.
7. **Trim the reading if required.** If the sensor reads consistently high or low against a known target, enter the difference as the **Calibration Offset** and send it again.

10 Troubleshooting

Symptom	Likely Cause	Action
No output / output at minimum regardless of target.	No power, reverse polarity, or wiring fault.	Verify supply level and polarity at the cable conductors; check loop continuity and GND reference.
Output pinned at full scale or bottom of span.	Target outside the `DMIN`/`DMAX` window, or window obstructed.	Confirm the live distance in the app (Read Once); clear obstructions; clean the optical window.
Reading noisy or unstable.	Mount flex/vibration, poor target reflectivity, or noisy target surface.	Stiffen the mount; square the aim; relocate for a more consistent surface.
Output jumps to its error level while the tank is undisturbed, with a **Blue–Blue** LED code.	The sensor has stopped getting a usable return — a filmed or fouled optical window, foam or floating debris on the surface, or a level that has moved outside the sensing range.	Clean the optical window; clear surface foam or obstructions; confirm the level is within range. The sensor recovers on its own once a valid measurement returns.
Reading appears frozen at one value.	Dark, absorbing, or highly angled liquid surfaces (for example black ink) return very little light, so only part of the sensor's field may be measuring.	Square the aim to the surface and recheck. If the reading is stale rather than genuinely steady, the **Blue–Blue** code appears within 60 s and the output moves to its error level (Section 10.1).
Reading biased / inconsistent with reference.	Calibration drift or dirty window.	Clean the window; re-trim endpoints; confirm with `CAL?`.
App / PC does not see the sensor port.	Sensor powered up without a host and entered logging mode, or the app needs a re-scan.	Click **Refresh** in the app; if still absent, reconnect USB to the PC and re-power the sensor, then connect promptly.
Current-loop output low or saturating.	Loop resistance above the drive limit, or wrong output mode.	Reduce loop resistance; confirm the output mode in the app matches the receiver.

10.1 Status LED Fault Codes

In normal, fault-free operation the status LED on the top face shows **solid green**. When one or more faults are active, the LED instead blinks a repeating **two-colour code** for each fault: the first colour for about 0.4 s, a brief off gap, the second colour for about 0.4 s, then a longer pause before the next code. Up to four active faults are shown in sequence, worst first, followed by a dark gap of about 3 s before the sequence repeats.

A few codes show the **same colour twice**, such as Blue–Blue. The brief off gap between the two flashes is the only thing that separates them, so count the flashes rather than looking for a change of colour: two short blue flashes is a fault code, whereas a steadily lit blue is not a code at all.

Faults are either **self-clearing** (the code stops once the condition passes) or **latched** (the code persists until the sensor is re-powered). A self-clearing fault that recurs persistently may become latched. If a latched fault returns immediately after a power cycle, contact support (Section 10.2).

LED code	Meaning	Behaviour	Suggested action
Blue–Red	Optical distance sensor not detected at power-up.	Latched	Re-power; contact support if persistent.
Blue–White	Optical distance sensor failed to initialise.	Latched	Re-power; contact support if persistent.

Status LED fault codes (continued)

LED code	Meaning	Behaviour	Suggested action
Blue–Yellow	Optical distance sensor rejected its configuration.	Latched	Re-power; contact support if persistent.
Blue–Cyan	Optical distance sensor failed to start measuring.	Latched	Re-power; contact support if persistent.
Purple–Red	Internal communication fault with the analogue output stage.	Latched	Re-power; contact support if persistent.
Yellow–Red	Stored configuration is invalid.	Latched	Reconfigure via the TLV Configurator (Section 7).
Red–White	Supply voltage below the operating range.	Latched	Check the supply level and wiring (Section 6).
White–Cyan	The unit recovered from an unexpected (watchdog) reset.	Latched	Re-power; contact support if it recurs.
Blue–Purple	Communication error with the optical distance sensor.	Self-clearing	No action if it clears; contact support if it recurs.
Blue–Blue	No usable measurement for more than 60 s. The reading shown is no longer live, so the output is driven to its configured error level rather than holding a stale value.	Self-clearing	Clean the optical window; clear obstructions, foam or splashing; confirm the liquid level is inside the sensing range.
Purple–White	Analogue output driver over-temperature.	Self-clearing	Reduce ambient temperature; check output loading.
Purple–Yellow	Current-loop open circuit detected.	Self-clearing	Check output wiring and loop continuity (Section 6).
Yellow–White	Internal memory (EEPROM) read/write error.	Self-clearing	No action if it clears; contact support if it recurs.
Cyan–Yellow	Problem writing to the USB logging drive.	Self-clearing	Reinsert or replace the drive (Section 8).
Cyan–Purple	USB host-mode (data-logging) fault.	Self-clearing	Reinsert the drive; re-power if it persists.

10.2 Support Contacts

For technical support, contact your local distributor. Customers in the US may contact Flatrock Systems directly through the website.

11 Maintenance

The TLV Sensor requires no routine service other than keeping the optical window clean.

- Inspect the optical window periodically for film, condensation, or deposits, which bias the reading.
- Wipe the window with a soft, lint-free cloth dampened with clean water. For stubborn residue, use a mild detergent solution and a soft cloth, then wipe with clean water. Do *not* use abrasives, alcohols, or aggressive solvents: the PEI optical window and the polycarbonate enclosure can craze, cloud, or stress-crack on contact with these.
- Keep the cable and its entry into the enclosure clean and dry. Do not open the enclosure; there are no user-serviceable parts inside, opening it breaks the environmental seal, and it may void the warranty.

12 Warranty

12.1 Warranty Period

The TLV Sensor is warranted against defects in workmanship and material for a period of two years (24 months) from the date of delivery. For customers outside the United States, warranty work is arranged and performed by the distributor from which the unit was purchased.

12.2 Exclusions

No compensation is given for direct or indirect consequential losses. No warranty coverage is provided where:

- changes were made without prior authorisation from Flatrock Systems;
- repairs were conducted incorrectly, with or without prior authorisation;
- the unit was operated outside its specified electrical, mechanical, or environmental ranges; or
- damage resulted from improper use.

13 Disposal

Dispose of the TLV Sensor in accordance with local regulations. The unit is electronic equipment and should be recycled through designated e-waste facilities rather than placed in general waste. Recycle packaging materials according to local guidelines.

14 Revision History

This table records the revision history of this document. The current document revision is shown on the title information page and is set by the `\docrev` macro at the top of the source. Add a new row for each released revision.

Revision	Date	Description of Change
1.0	2026-06-23	Initial release.
1.1	2026-07-24	Configuration section brought up to date with the TLV Configurator app: sensor name, calibration offset, error output, status LED, log variable selection, config profiles, firmware updates, terminal diagnostics, and Advanced Mode. Data logging section updated for selectable log variables and log-file rotation; corrected the previous statement that the Terminal tab writes a CSV file.