ST0001

HAUCS-GUI User Manual

Writer: Alisa Kunapinun

2025/07/15

HAUCS-GUI User Manual

1. Overview

Introduction

HAUCS-GUI is a user-friendly graphical interface software developed for **real-time monitoring of dissolved oxygen (DO)** levels in aquaculture ponds using mobile sensors installed on a field truck. The software is designed to run on **Raspberry Pi 4** with a touchscreen, requiring minimal interaction by the user.

Purpose of the System

The system is intended to help farmers and field operators monitor DO levels efficiently and automatically, even if they do not have a technical background. Once powered on, the system:

- Starts automatically
- Connects to Bluetooth DO sensors
- Displays real-time DO measurements
- Uploads results to the cloud (Firebase)

Users can view current oxygen levels, switch between units (mg/L or % saturation), calibrate the sensor, and review the measurement history — all through a simple and intuitive touch interface.

Key Features

- Automated startup and data upload
- Touchscreen operation with large fonts for outdoor readability
- Automatic Pond ID detection via GPS
- DO sensor calibration and history logs
- Bluetooth-based DO measurement with optional YSI sensor support
- Offline operation and data buffering when internet is unavailable

Target Users

- Farmers, aquaculture staff, or general field operators
- Government survey teams or engineers requiring mobile DO monitoring
- Anyone needing DO data without complex configuration

2. System Setup & Installation

The HAUCS-GUI software is **pre-installed** on the device provided with the field kit. Users do **not need to install or configure** the software themselves. The system is ready to use once powered on.

How to Start the System

- Turn on the Raspberry Pi by pressing the power switch on the device.
- The system will automatically launch HAUCS-GUI after boot.
- Wait for the main interface to appear (within 1–2 minutes).
- Once loaded, the screen will display the current pond location and wait for sensor activation.

No login, setup, or command-line action is required.

Hardware Configuration (Pre-configured)

The system hardware is already assembled and tested. The main components include:

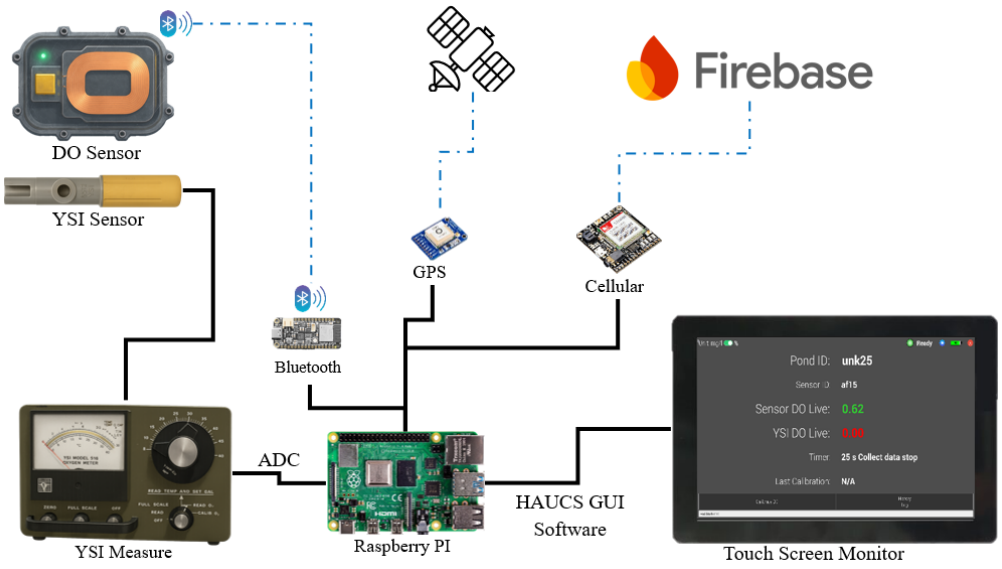


Figure 1 System Hardware and Communication Overview

Figure 1 shows the hardware architecture of the HAUCS-GUI system, including sensor input, Bluetooth/GPS communication, data processing via Raspberry Pi, and cloud upload to Firebase. The system displays real-time data on a touchscreen monitor for the user.

Component	Description
Raspberry Pi 4	Main processor with Raspberry Pi OS
Touchscreen Display	Outdoor-readable, high-resolution screen
Bluetooth DO Sensor	For wireless DO measurement
GPS Module	For automatic Pond ID detection
Cellular Modem (4G)	For internet connectivity and cloud upload
Optional YSI Sensor	For manual DO comparison (via ADC input)

Software Environment

Item	Details
OS	Raspberry Pi OS (with desktop GUI enabled)
Programming Language	Python 3.9+
GUI Framework	PyQt5
Pre-installed Libraries	numpy, pandas, matplotlib, firebase-admin, etc.

The software is configured to:

- Auto-launch on boot
- Auto-detect all connected hardware
- Run with minimal user intervention
-

No Installation Needed

There is no need to install, update, or modify the software. Any required updates will be handled by the engineering team during maintenance sessions.

🔒 **Important**: Do not attempt to install other programs or modify system settings, as it may affect data collection and cloud upload functionality.

3. Software Operation

This section provides a complete guide to using the HAUCS-GUI interface, including how to perform DO measurements, view results, and configure settings. The GUI is designed for simplicity, large-font readability, and minimal user interaction.

Main Interface Overview

When the system boots up, the main interface of HAUCS-GUI will appear automatically. This screen is the primary control panel used throughout the dissolved oxygen (DO) measurement workflow.

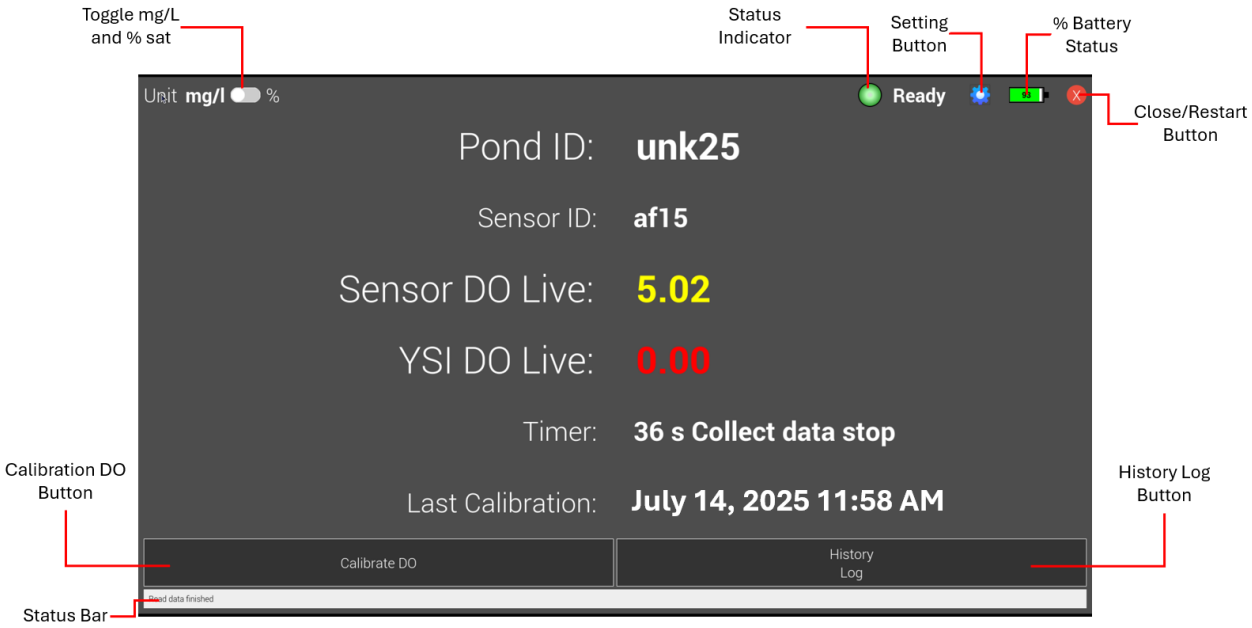


Figure 2 Main Interface Layout of HAUCS-GUI. The GUI shows current pond information, sensor status, and real-time DO values. Key functions such as calibration, settings, and history log are accessible via large touchscreen buttons.

Interface Elements

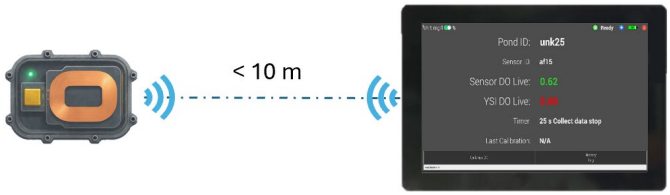
Element	Description
Unit Toggle (Top-Left)	Switch between mg/L and % saturation. Values are always internally stored in % saturation.
Pond ID	Displays the current pond identifier as detected via GPS.
Sensor ID	Live DO value measured via Bluetooth sensor (colored for quick status check).
YSI DO Live	Optional value from the analog YSI sensor (shown in red if zero or missing).
Timer	Counts how long the sensor has been submerged; turns green after 30 seconds.
Last Calibration	Shows the timestamp of the last DO sensor calibration. *(e.g., "July 14, 2025, 11:58 AM")*
Calibration Button	Tap to calibrate the DO sensor (confirmation dialog will appear).
History Log Button	Tap to review the DO measurement history (last 48 hours).
Settings Button (Gear)	Access configurable parameters: minimum DO threshold, optimal DO level, and result window timeout.
Battery & Status Icons	Show system readiness and battery level.
Program Exit Button	Tap to close or restart the program (password protected).

Performing DO Measurements

This section explains how to perform a dissolved oxygen (DO) measurement using the HAUCS-GUI system, from sensor connection to viewing results.

Step 1: Preparing the Sensor Before Power-On

- Place the Bluetooth DO sensor within 10 meters of the Raspberry Pi device before turning it on.

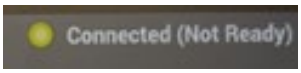


- This ensures stable pairing between the sensor and the device at startup.

> ⚠ **Note:** The DO sensor may be in **sleep mode** when first powered on. Connection may take a few extra seconds but will complete automatically.

Step 2: Powering On & Connection Process

- Turn on the system using the **external power switch**.
- The GUI will launch automatically.
- The **Status Indicator** will follow these stages:
  - 🟡 **Yellow = Initializing (Connecting)** – lasts ~5 seconds



  - 🟢 **Green = Ready** – system is fully connected and ready to measure

> ⚠ **Warning:**
> **Do not submerge the DO sensor during system startup.**
> The sensor must remain in air to complete internal initialization and environmental checks. Premature submersion may cause inaccurate readings.

> ⏱ Connection may take **up to 1 minute** in total depending on sensor wake-up. Be patient and wait for the **green "Ready" status** before proceeding.

Step 3: Start Measurement – Submerge the DO Sensor

- Once the sensor is submerged into the pond, the system will **automatically detect it and begin measurement**.
- The **Status Indicator** may briefly flash 🔴 **red (Disconnected)** if Bluetooth signal drops underwater — this is **expected** and does not affect measurement.

- The **Timer** on screen will start counting up in seconds, and the text will display: "**Collecting Data**"

Step 4: Wait for 30 Seconds

- The system needs at least 30 seconds to acquire stable data.
- After 30 seconds, the timer message changes to: "**Collecting, Ready to pick up**"

✅ This means it is now safe to lift the sensor from the water.

⚠️ **Important:** Lifting the sensor **too early** may result in inaccurate data.

Step 5: Lift Sensor – Stop Measurement

- Once the sensor is removed, the message changes to: "**Collect data stop**"

- The system will then process the data for 2–3 seconds and display the Result Window.

Step 6: Check Pond ID & Review Results

The Result Window shows:

- Pond ID (auto-detected via GPS)
- DO values (Sensor + YSI)
- Temperature, Pressure
- A curve-fit graph (if engineering view is enabled)

If the Pond ID is incorrect, tap the Edit button and enter the correct pond number.

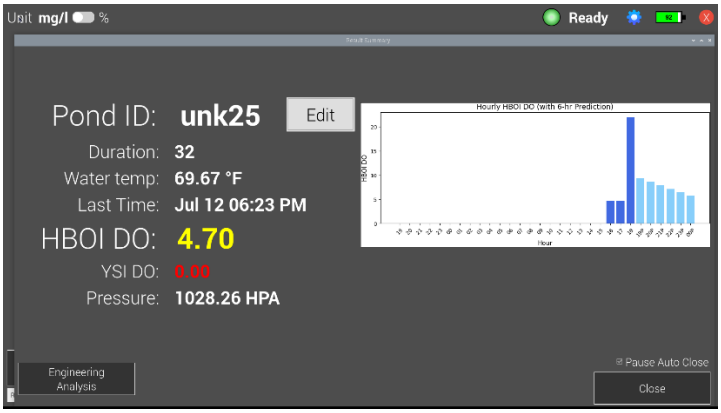


Figure 3 Result Window screen

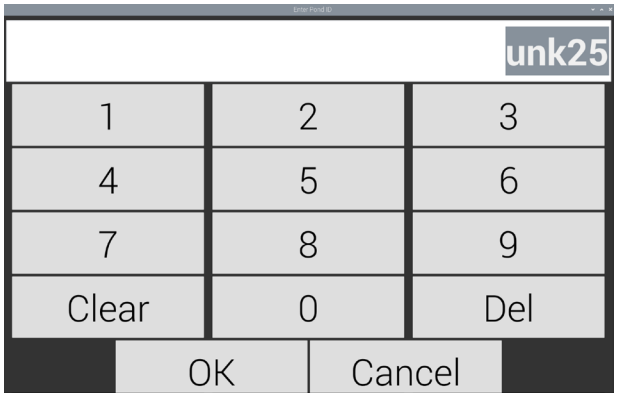


Figure 4 Pond ID Editing screen

⏱ **Auto-close in 10 seconds**:

- The result window will close by itself after 10 seconds.
- To pause the countdown, **tap anywhere on the screen**.

🔧 **Tip:** The auto-close time can be adjusted via the Settings menu.

Step 7: System Ready for Next Measurement

- After the result window closes, the system returns to the Main Interface.
- It is now ready for the next DO measurement cycle.

💡 Even if the result window is left open, the system will **automatically close it** when a new measurement starts.

💡 Always **double-check the Pond ID** before proceeding to avoid incorrect data records.

Result Window

Once a DO measurement is completed, the system displays a **pop-up Result Window** summarizing the results, sensor readings, environmental data, and predictive analysis. This window is shown for a few seconds before the system returns to the main screen.

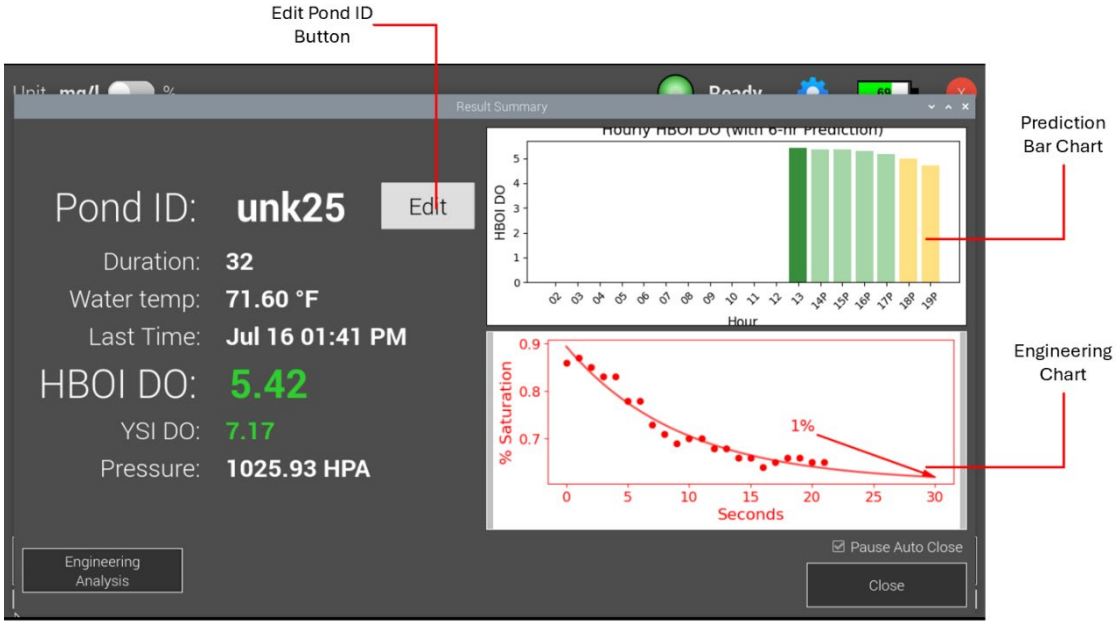


Figure 5 Result Summary Window. The result window displays final DO values, sensor information, and prediction/engineering charts. The Pond ID can be corrected if GPS detection is inaccurate.

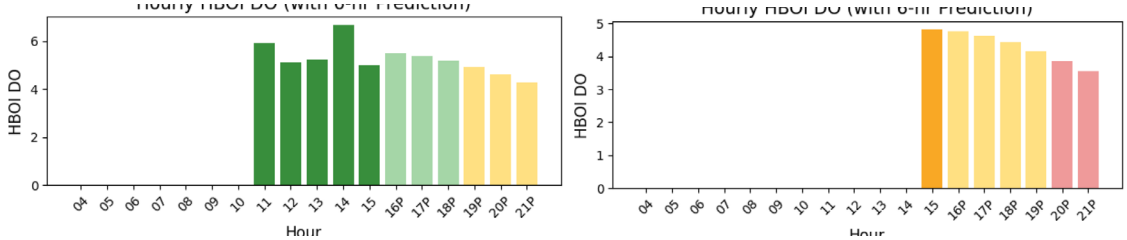
Information Shown on the Result Window

Field	Description
Pond ID	Identified pond number (can be corrected by tapping **Edit**)
Duration	Total time (in seconds) the sensor remained in the water
Water Temp	Real-time water temperature (°F)
Last Time	Timestamp of measurement completion
HBOI DO	Final DO value calculated from the sensor using curve fitting (highlighted)
YSI DO	Optional value from the manual YSI sensor (shown in red if missing or zero)
Pressure	Atmospheric pressure at the time of measurement

Graphical Charts

- **Prediction Bar Chart:** This bar chart provides a visual forecast of DO (Dissolved Oxygen) levels for the next 6 hours. It helps users anticipate oxygen trends and take action when necessary.
    - The chart includes both historical and predicted values.
    - Darker bars represent DO values already measured (past and current).
    - Lighter bars represent predicted DO values for the next 1 to 6 hours.
    - The height of each bar corresponds to the DO level (either in mg/L or % saturation, based on the selected unit).

    Bar colors indicate oxygen status:
    - 🟢 Green: DO level is good — no action required.
    - 🟡 Yellow: DO is dropping — monitor closely.
    - 🔴 Red: DO is low — add oxygen immediately.



    This tool is designed to assist field operators in making real-time decisions about oxygen management in aquaculture ponds.
- **Engineering Chart (Hidden by default):** Shows raw DO values and the curve-fitted trend used to compute the final HBOI DO. Accessible via the Engineering Analysis button (bottom left).

User Actions in Result Window

- **Edit Pond ID:** Tap the Edit button if the auto-detected Pond ID is incorrect. After correction, tap OK to confirm. The new Pond ID will be saved with the record.
- **Pause Auto-Close:** Tap anywhere on the screen to pause the countdown that closes the result window. If no action is taken, the window will close automatically after 10 seconds.
- **Close Button:** Tap Close to dismiss the result window manually.

> ⚠ **Important:**
> The Pond ID must be checked and corrected **before the result window closes**. Incorrect IDs will result in **mis-logged data** and should be avoided.

> 🔧 **Tip:** The result auto-close time can be configured in the **Settings Menu**

History Log

The History Log provides a summary of recent DO measurements taken by the system, allowing users to review previous values for tracking and verification. It is accessible anytime by tapping the History Log button on the Main Interface.

Figure 6 History Log Screen (Unit Toggle Examples). The displayed DO values depend on the selected unit — either mg/L or % saturation — while the data remains internally stored as % saturation. Color coding reflects status based on threshold settings.

Displayed Fields

Each row in the table corresponds to a single measurement session and includes:

Field	Description
Date	Date of measurement (Local time)
Time	Time of measurement (Local time)

Pond ID	Identified or corrected pond number
HBOI DO	Final DO value from Bluetooth sensor (color-coded)
YSI DO	Optional reference value from YSI sensor (0.0 if unused)
Temperature	Water temperature (°F)
Pressure	Atmospheric pressure (hPa)

Color Coding Logic

- **Green**: DO value is above or equal to "good DO" threshold
- **Yellow**: DO is above minimum but below good threshold
- **Red**: DO is below the minimum DO or missing

🎛️ The thresholds for **“Minimum DO”** and **“Good DO”** can be adjusted in the **Settings menu**. The default values are:

- **Minimum DO**: 4.0
- **Good DO**: 5.0

Notes on Usage

- **Two-Day Limit**: Only the last 48 hours of data are shown to preserve performance and screen clarity.
- **Read-Only**: Data cannot be edited to ensure integrity and traceability.
- **Scroll Support**: Users can scroll vertically to see earlier records.
- **Unit Sync**: DO values shown follow the unit (mg/L or %) currently selected on the Main Interface, but are always stored internally as % saturation.

🔒 **To exit this screen**, press the **“Close”** button on the lower right corner.

Settings

Settings Menu

Users can open the settings menu by tapping the gear icon at the top-right corner of the main GUI. This menu allows you to configure system thresholds and display timing.

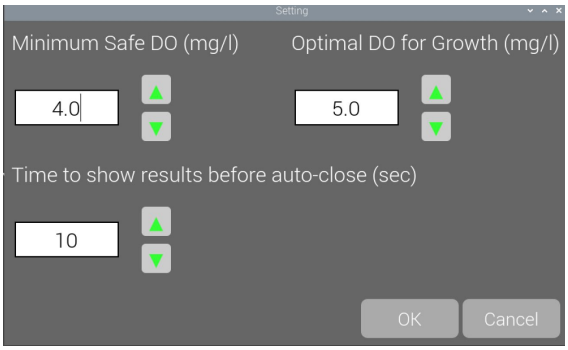


Figure 7 Settings Dialog. Three configuration parameters can be set by the user

Setting	Description
Minimum Safe DO	Threshold for DO warnings (default: 4.0 mg/L)
Optimal DO for Growth	Target range for healthy DO (default: 5.0 mg/L)
Auto-Close Timer	Duration (in seconds) before the Result Window auto-closes (default: 10 sec)

All thresholds apply across all units (mg/L and % saturation) and directly influence **color coding** in the History Log.

Calibration DO

DO Sensor Calibration

Calibration ensures that the Bluetooth DO sensor provides accurate readings in field conditions. Calibration is initiated manually and should be performed **at least once a week**.

Access calibration via the **"Calibrate DO" button** at the bottom left of the main screen.

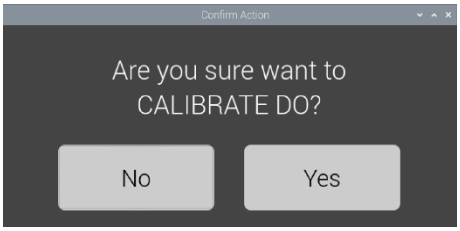


Figure 8 Calibration Confirmation Dialog

Calibration Procedure

1. Tap the "Calibrate DO" button on the main GUI.
2. Submerge the DO sensor into clean water and remove it.
3. Ensure the sensor surface is moist but not dripping.
4. Tap Yes to confirm calibration in the dialog.
5. Upon success, the timestamp of the last calibration will be updated on the main screen.

💡 Tip: Calibration helps correct sensor drift and is highly recommended before any critical DO measurements.

🔒 Note: Calibration does not affect any prior measurement history. It only influences subsequent readings.

Unit Toggle

The **Unit Toggle** feature allows users to choose how dissolved oxygen (DO) values are displayed on the interface — either in **milligrams per liter (mg/L)** or **percent saturation (% sat)**. This toggle is provided for flexibility in field use, where different users may prefer different units depending on training or regulatory context.

How to Use

The toggle switch is located at the top-left corner of the main interface.

- Simply tap the switch to alternate between mg/L and %.
- The displayed values in:
- Main screen (DO readings)
- Result Window
- History Log: will update immediately to match the selected unit.

Figure 9 Unit Toggle button

Internal Consistency

Regardless of the unit displayed on screen:

- All data is internally logged and stored in % saturation for consistency and compatibility with cloud services and prediction models.
- The History Log will follow the currently selected unit, but all uploads and archives retain the % saturation format.

Auto-Upload & Offline Buffering

The upload system in HAUCS-GUI runs automatically in the background and does not require any user action. It ensures that DO measurement data is reliably saved and uploaded to the Firebase cloud — even under unstable network conditions.

Upload Workflow

1. After each measurement, when the Result Window is closed (manually or auto-closed), the data is:
   - Immediately saved as a .txt file in the unsaved_json folder
   - Added to an internal upload stack
2. If internet is available:
   - Files in the stack are uploaded immediately in background threads
   - Successfully uploaded files are moved to the completed_json folder
3. If the system shutdown before uploading:
   - Upon restart, the system scans **unsaved_json** for unuploaded files
   - These files are re-added to the upload stack and the loop resumes automatically

🔧 **Engineer Note:** The system uses internal retry logic and local storage to handle unstable connections without data loss.

👨‍🌾 **User Note:** No internet setup or cloud configuration is required by the user. Just **turn on the system and measure DO as normal**.

Password-Protected Features

Some sensitive operations in HAUCS-GUI are protected by password to prevent accidental program closure, especially in the field.

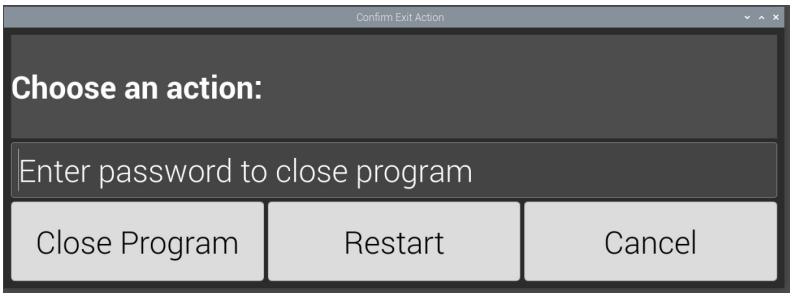


Figure 10 Secure Exit Dialog

How to Access

- Tap the red "X" button in the top-right corner of the main interface.
- A dialog will appear with three options:

Option	Description
Close Program	Requires password **98765** to proceed. Prevents users from shutting down without knowing how to relaunch the GUI.
Restart	Immediately restarts the Raspberry Pi without requiring a password. Useful if the GUI becomes unresponsive.
Cancel	Dismisses the dialog without any action.

Security Note: The program is designed to **auto-start on boot**, so users should rarely need to shut it down. Only engineers or advanced users should perform full exits.

4. Engineering Setup

Engineering Chart (DO curve fitting)

The Engineering Chart provides a graphical view of raw DO sensor data over time, overlaid with a fitted exponential decay curve. This chart is primarily for internal use by engineers and researchers to validate sensor behavior and assess signal quality.

Raw Data Sampling

- DO Sensor (Bluetooth): Captures one data point per second (1 Hz)
- YSI Sensor (Optional, via ADC): Captures data at 0.1 second intervals (10 Hz)
- Each data point consists of timestamped % saturation readings

Curve Fitting Method

To estimate the final DO value, the system performs **nonlinear curve fitting** using the following exponential model:

$$DO = a * e^{-bx} + c$$

This model approximates the typical sensor response curve in which DO values settle after immersion. The extrapolated value at **t = 30 seconds** is defined as the **final HBOI DO**.

Fallback Condition

If curve fitting fails due to:

- Fewer than 5 valid data points, or
- Excessive noise / poor convergence,

The system will automatically fallback to the mean of DO values.

This ensures robustness in field conditions where ideal sensor behavior may not be guaranteed.

Chart Visibility

- The Engineering Chart is hidden by default
- It can be accessed via the “Engineering Analysis” button on the Result Window
- Engineers can inspect curve smoothness, raw DO points, and fitting residuals visually

⚠ **Note:** This feature is primarily intended for calibration, debugging, and research. Normal users do not need to interact with this chart during standard operation.

Engineering Configuration: setting.setting

Engineers can modify internal storage paths and file handling behaviors via the setting.setting configuration file. This file is not accessible via the GUI and should be edited only by experienced users.

Editable Parameters Include:

Parameter	Description
unsaved_json	Path to folder where raw data is saved before upload
completed_json	Path to folder where files are moved after successful upload
log_dir	Path for storing detailed system logs or debug files
(others)	Additional engineer-level options for tuning system behavior

🛠️ Engineers can edit this file manually via SSH or by accessing the Raspberry Pi's file system. Any changes will take effect the next time the program is started.

⚠️ **Warning:** Incorrect path changes may result in upload failure, data loss, or system instability. Always verify new paths are writable and mounted correctly (e.g., USB storage, SD card folders).

Raw file structure (unsaved_json, completed_json, etc.)

HAUCS-GUI logs each DO measurement in structured .txt files that are first stored in the unsaved_json folder. These files are automatically uploaded to the cloud (Firebase), and once successfully uploaded, they are moved to the completed_json folder. This file-based logging system ensures traceability and offline resilience.

File Naming Convention

Each file is named using the UTC timestamp of when the result was created:
YYYYMMDD_HH-MM-SS.txt

File Content Format

```
do=0.8207142857142858
init_do=3568.0
init_pressure=1018.85
lat=None
lng=None
pid=unk25
pressure=[1026.2085714285715]
sid=af15
temp=[70.07857142857144]
batt_v=3.57
type=truck
ysi_do=0
message_time=20250710_21:33:55
```

Field Descriptions

Key	Description
do	Final DO value (in % saturation)
init_do	Initial raw sensor value before fitting
init_pressure	Air pressure during calibration
lat, lng	GPS coordinates (may be `None` if unavailable)
pid	Pond ID, either GPS-derived or user-edited
pressure	Water pressure during DO measurement (list format)
sid	Sensor ID of Bluetooth DO device
temp	Water temperature during DO measurement (list format)
batt_v	Battery voltage at time of reading

type	Device type (e.g., "truck")
ysi_do	Reference value from YSI sensor (if available; usually 0 if unused)
message_time	UTC timestamp of when data was logged

📁 Files in `unsaved_json` will remain until successfully uploaded.
Once uploaded, they are moved to `completed_json` to ensure reliable traceability.

🛠️ Engineers may access these logs for debugging, audit tracking, or offline analysis.

Log Files & System Status Tracking

HAUCS-GUI maintains a detailed log of internal operations for each session. These logs help engineers monitor system behavior, diagnose sensor or network issues, and verify data processing. Logs are created automatically for **every program startup**, and stored persistently.

Log File Location & Naming

- Default directory: /log
- File name format: log_YYYY-MM-DD-HH-MM-SS.log

🔧 Engineers may change this directory using the `log_dir` field in `setting.setting`.

Log Entry Format

Each line in the log file includes:

- Timestamp
- Log Level (INFO, WARNING, or ERROR)
- Message

Example log snippets:

```
2025-07-11 15:45:51,076 INFO: DO Sensor Starting
2025-07-11 15:45:56,739 INFO: GPS Starting
2025-07-11 15:45:56,749 INFO: YSI ADC initialize finish. YSI ADC version: 1.2.2
2025-07-11 15:45:56,751 INFO: use firebase key:/home/haucs/Desktop/HAUCS_GUI/fb_key.json
2025-07-11 15:45:59,113 INFO: first time connected to the payload (boot up)
2025-07-11 15:46:04,950 INFO: Initialize sensor, get init_do, init_pressure, battery
2025-07-11 15:46:18,743 INFO: Sensor is underwater, while still connecting. 1 0
2025-07-11 15:46:22,190 WARNING: BLE connect failed - maybe underwater
2025-07-11 15:46:35,490 INFO: reconnect after disconnect - finished sampling and re-emerge
2025-07-11 15:46:48,312 INFO: Data collected: unk25, DO:0.7355995243274448
2025-07-11 15:46:48,800 INFO: Using categorical units to plot a list of strings that are all parsable as floats or dates. If these strings should be plotted as numbers, cast to the appropriate data type before plotting.
2025-07-11 15:46:48,803 INFO: Using categorical units to plot a list of strings that are all parsable as floats or dates. If these strings should be plotted as
```

Log Levels

Level	Description
INFO	Standard system operations such as sensor startup, data collection, calibration, uploading, and shutdown.
WARNING	Non-critical failures such as temporary Bluetooth disconnects or upload delays due to network issues. These do **not interrupt** the measurement loop.
ERROR	Critical failures that may stop the program or disrupt measurements. Engineers should investigate immediately.

🛠️ Engineers can inspect these logs to:

- Verify upload integrity
- Detect measurement delays
- Confirm Bluetooth/GPS connection behavior
- Audit the number of sessions per day

Measurement History Log File

HAUCS-GUI generates a **daily summary log file** for each field unit to keep track of all DO measurement sessions. This file provides a convenient record of measurement metadata and is useful for post-hoc review, analysis, and audit.

Location & Naming Convention

- Folder: /database_truck
- Filename format: {truck_id}_YYYY-MM-DD.csv

When is it created?

- The file is updated immediately after the Result Window is closed, whether by timeout or user action.
- Each row corresponds to one completed DO measurement session.

File Structure

Column	Description
time	Local time (HH:MM:SS) when measurement completed
Pond ID	Pond identifier (GPS-based or edited by user)
HBOI DO	Final DO value from curve fitting (in % saturation)
YSI DO	YSI sensor reading (0 if not used)
Temperature	Water temperature (°F)
Pressure	Atmospheric pressure (hPa)
do csv	File path to raw DO time-series data (.csv)
upload status	TRUE if Firebase upload was completed; FALSE otherwise
message_time	UTC timestamp for logging consistency
ysi csv	File path to raw YSI time-series data (.csv)

Key Points

- time is recorded in local time for user clarity
- message_time remains in UTC for internal consistency and upload alignment
- upload status will change to TRUE once the Firebase upload is confirmed
- File paths (for DO and YSI .csv) allow engineers to retrieve high-resolution time-series data for any session

🛠️ This file serves as an important **bridge between the GUI-level summary (History Log screen)** and the **backend raw data**.

Engineer Access

Although this file is updated automatically by the system, engineers can:

- Use it for reconciling missing uploads
- Check for measurement anomalies across time
- Cross-reference file paths to DO/YSI charts