MicroEDS

Version 1.0

User Manual

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Chapter 1: Introduction and initial setup

Purpose of the manual

An **EDS** is an **early detection system**, which is a system that uses unsupervised machine learning technology to detect abnormal events in data. As a Java-based system, MicroEDS may run on top of any the environments listed below:

1. A single-board computer (SBC) such as the Raspberry Pi and its compatibles
2. Windows 10 and 11
3. Linux
4. Any embedded system that runs JVM from Oracle

We hope you will find this user manual easy to use and understand. If not, please use our customer suggestion service on our website to suggest improvements to this user manual.

Intended audience

This manual is designed for both inexperienced and experienced users; it includes basic examples for individuals using an EDS system for the first time, but it is also aimed at experienced engineers who are familiar with the concept of an EDS.

Scope

This manual covers the installation, setup, usage, and maintenance of MicroEDS. It focuses on how to incorporate the EDS into an existing system.

Product overview

The current version of MicroEDS was mainly designed to detect events in a distribution system for drinking water; however, the user can adjust this version to operate in other domains. The manual covers installation, model setup and training, runtime monitoring, communication with other systems, and troubleshooting. The installation kit includes a demo database, and instantly puts the system in Run mode. However, it also provides the user with a comprehensive explanation of how to build a database and link it to other organisational systems.

Manual version history

VERSION NO.	DETAILS
Version 1	The first technical manual was issued in MARCH 2024.

Safety Precautions

- Please test MicroEDS in a lab environment before it is operated under real-world conditions.
- The algorithm is designed to process records at a rate of a maximum of 10 per minute. If you need a more loaded application, please consult our technical team.
- If you are using MicroEDS on top of Raspberry Pi (or a compatible system), please follow the manufacturer's guidelines for your hardware to ensure safe and stable performance.

Key terms & definitions

Term	Meaning
EDS	Events Detection System. Designed to read raw data online and implement machine learning algorithm for detecting abnormal situation.
EVENT	A situation of abnormal combination of data
RawData	Field data based on real time sensors
Detectors	Set of algorithms that performs the machine learning algorithms.
Model	Set of Variables, Detectors and Rules which define the EDS model.
Alerts	A message sent to hosting system about abnormal situation in data.

Terminology used in notifications

- **Info:** Indicates that MicroEDS is giving information about normal operations
- **Warning:** Indicates potential safety hazards that may damage hardware or cause data loss if ignored
- **Caution:** Alerts users to potential risks that could lead to suboptimal performance or gameplay issues if not avoided
- **Error:** Indicates that MicroEDS cannot perform a given task, and may stop functioning.

- **Critical:** Indicates that MicroEDS is not functioning adequately in terms of data monitoring and providing alerts to the hosting system

System requirements

Before installing MicroEDS, please ensure that the hosting hardware meets the following minimum requirements:

Environment	Requirements
Raspberry Pi or similar hardware	Raspberry Pi 4, Version B with 4G RAM SDCard with minimum 32G Download MicroEDS for SBC
VirtualBox	Window 10 with minimum 8G RAM Oracle VirtualBox (latest version) Download of the MicroEDS virtual disk
Docker	Latest version of Docker with a minimum of 8G RAM Download of the MicroEDS Docker image for Windows (or Linux)

Installation

Option A: Raspberry Pi or similar hardware

- Download the MicroEDS Image for SDCard from our website
- Burn the image onto an 32G SD card using standard burn software
- Insert the SD card into the device
- Power on the target Raspberry Pi, and make sure the device has an HDMI connection to a screen; the keyboard and mouse are hooked to the device

Option B: VirtualBox

- Make sure to use the latest version of VirtualBox
- Download the MicroEDS virtual disk from our website
- Import the virtual disk into the VirtualBox environment
- Run the virtual image

Option C: Docker

- Ensure you are using the latest desktop version of Docker
- Download the MicroEDS docker image from the Docker hub
- Start the Docker image

Quick start guide

For learning and demonstration purposes, we recommend that the user become familiar with the system by using the demo database provided with the initial installation. Most of the examples and screenshots in this document refer to the demo database.

License registration

The MicroEDS system is provided with a demo license, which is a fully functional license that stops functioning after three hours. In order to reactivate the system functionality, the system must be rebooted. This feature enables the user to test MicroEDS thoroughly.

This document includes a chapter that gives details of how to purchase a commercial license. The terms of this license are provided on the company's website.

Learning roadmap

We suggest the following roadmap for learning about a MicroEDS system.

Step	Activity and achievements
1	Run the demo database
2	Learn about variables
3	Learn about charts
4	Learn about detectors
5	Learn about alarms and events
6	Define the destination for system alarms and events
7	Make changes to the demo model and observe the results
8	Do some model maintenance work
9	Import data to the model, export reports from the model
10	Build your own model

Overview of features

The following is a short list of the activities of the MicroEDS system.

- Setting delay times for event alarms
- Learning process control limits to minimise the number of false alarms
- Detecting abnormal combinations
- Detecting single sensor short deviation
- Observing and displaying alerts about communication problems
- Detecting fixed values
- Maintaining filter sensors
- Detecting abnormal jumps
- Detecting changes in baseline, pattern and noise
- Detecting the effects of physical measurements (temperature, pressure) on quality measurements
- Displaying alerts for constant drift
- Detecting deterioration in quality

Chapter 2: Running the demo database

Chapter highlights

- Installing and running the demo database.
- What is the demo database, and how can it be used in the stages of learning?
- Menu items
- Components and features of the main screen
- Running and pausing the system

2.1 Installing and running the demo database

In order to activate the demo kit, download the demo file from the company's website and burn the file onto a 32G SD card. Insert the SD card into the Raspberry Pi version 4 unit and reboot it. The system will boot automatically, and the screen shown in Figure 1 will appear.

Note: Before activating the SD card on the Raspberry Pi unit, please ensure the unit has Internet access.

The user can communicate with the unit in two ways.
Option 1: Connect a screen, keyboard, and mouse to the unit's USB inputs
Option 2: Use RealVNC

The RealVNC connection is installed in the Raspberry Pi's operating system; however, it must be activated from a registered RealVNC account. The user should read the instructions in the RealVNC explanatory documents regarding activation of this connection.

What is included in the demo database?

The demo database includes a table of 40,000 sample records from a water quality monitoring station. A dedicated model was calibrated based on these records to demonstrate the operation of MicroEDS. All detectors are used within the model. It is also possible to generate all the graphs and reports included in the software from the model.
In order to see how the unit transmits alerts to an external source, the parameter file must be updated with the IP address of the MSMQ server that will receive the units. To install and activate this service, the user should read the chapter on connecting to external units in this manual.

How do I build and use my own model?

In order to build a model that is adapted to your needs, you should follow the process set out in Chapter 8: Building a Model. You can always go back and activate the sample database using the file provided on the company website.

2.2 Main screen

Figure 1 shows the main screen of the system, which is displayed when the system wakes up after a boot procedure. The header of the screen includes an icon, the name of the system and the version.

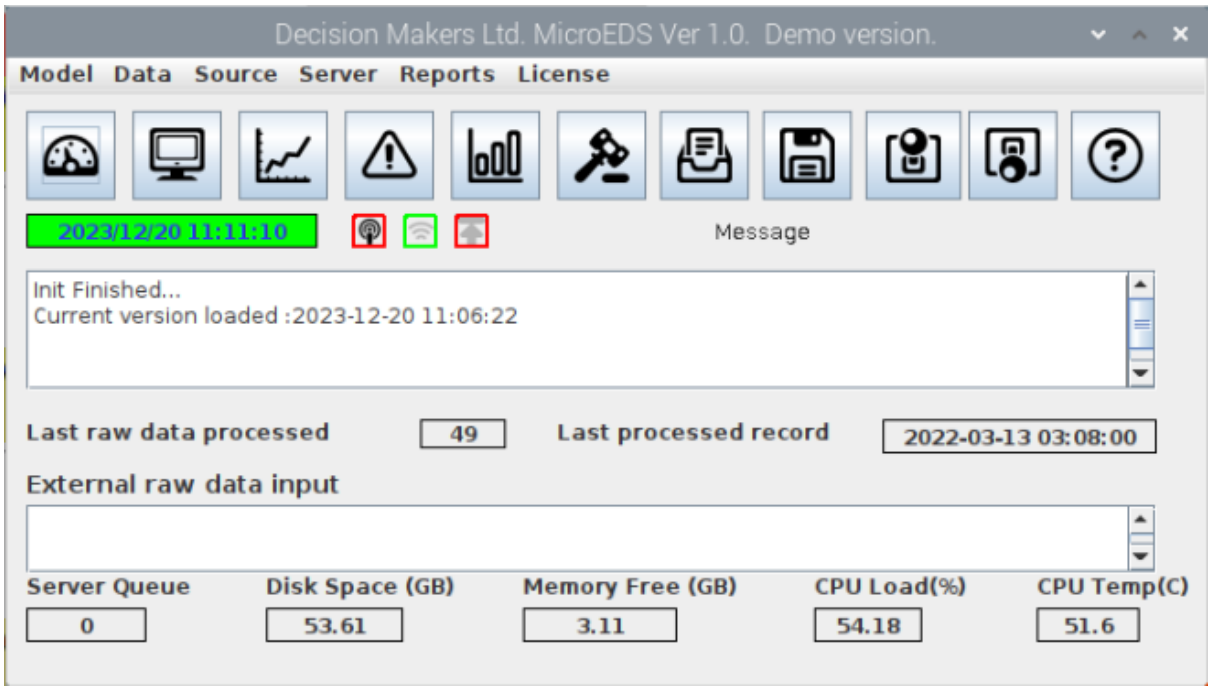
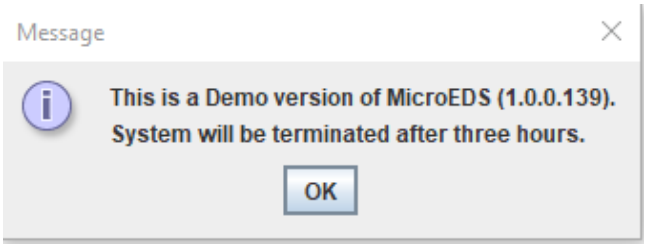


Figure 1: Main screen

Note: Tooltip text for items is displayed when the mouse hovers over any screen element.

Once the system is loaded, the type of license is checked. If no license exists, a message is displayed below. Although the demo system is fully functional, it will stop running after three hours.



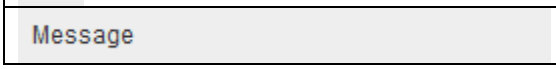
The second line includes a drop-down menu. Please refer to Table 1, which details the functionality of the menu items.

Table 1: Menu items

Main menu	Sub-menu	Functionality
Model	Vars	Define system variables
	Detector	Define and set system detectors
	Rules	Define rules
	Filters	Define filters
	Parameters	Set parameter values
	Version	Manage model versions
	Validation Log	See validation log
	Training	Train the model
Data	Import	Import data from the CSV file
	Restructure	Restructure the model data table
	Template	Import the model definition from a template
	Create DB	Create an empty database
	Reset History	Reset the historical processing flag
	Backup DB	Backup the database
Source	Non-pivoted	Define the source as a non-pivoted file
	Pivoted	Define the source as a pivoted file
	ModBus	Define the data source from Modbus
Server		Define the target server
Reports	Validation	Generate a validation report
	Events Minutes	Generate events by minutes
	Historical Event	Generate event list
License		Activate license

Icon	Functionality
	Dashboard: Shows the last process values
	Model data: Shows the model data table and lets the user see historical records
	Charts: Enables the user to view several charts
	Events: Enables the user to view current events
	Density: Shows a density table that indicates the frequency of data combinations
	Rule: Shows the current status of system rules
	Log: Shows the system log
	Save: Saves the current model definition to the database
	Run: Activates the system engine
	Pause: Stops the system engine
	Help: Shows the system version and exit door

The fourth line includes several elements, which are explained below.

Element	Indication
	Current system date and time
	Modbus connection indicator
	Internet connection
	MSMQ server indicator
	Last info message

The main log window is located in the centre of the screen, and displays the log messages from the system. For example, in Figure 1, the messages indicate that the system has finished its initialisation procedure, and the model version from 2023-12-20 11:16:22 (date and time) has been located from the database.

Raw data processing and inputs

The primary log system positions the raw data field indication. This log includes:

- Seconds since the last processing of raw data
- Timestamp of the last raw data record
- The last raw data the system received (this field is active only if raw data are injected from an external source into the system)

System health indicators

Several health indicators are displayed at the bottom of the screen, as shown in Table 2.

Table 2: System health indicators

Field	Indication
Server Queue	Number of messages waiting to be transferred to the server
Disk Space	Free disk space
Memory Free	Free memory space
CPU Load	Average load of the CPU
CPU Temp	Internal temperature of the CPU (in case running on Raspberry)

The system is refreshed every second, regardless of the state of the system.

2.3 System states

The system has several states, which are indicated by the background colour of the date-time field located at the upper left side of the screen, below the toolbar buttons. Table 3 summarises the different states, their meaning, and how each state can be entered.

Table 3: System states

State	Colour Indication	
Initialisation	Cyan	The system is loading the model and initialising the working objects
Run	Green	The system is performing a normal routine
Pause	Grey	The system is in a paused state: records are not processed, but data can be sent to the system
Error	Red	The system has encountered an error that prevents it from performing its routine; see the log file for details

- When the system is in the Initialisation state, nothing can be done, and the user must wait.
- In the Run state, the stop button on the upper toolbar can be paused.
- In the Pause state, the system can be set to Run mode using the Run button in the upper toolbar. Please note that the validity of the model is checked before the system state is changed from Pause to Run. A message is displayed if this check fails and the system remains in the Pause state.
- In the Error state, the log file should be examined to determine the appropriate action.

2.4 Data flows

The system has three primary data flows:

- Raw input data flow: This includes reading and accepting raw data and storing it in the model data table. A detailed explanation of this data flow is given in Chapter 5.
- Data processing: This includes reading records from the model data table, processing them, storing the results in the database and generating alarms if necessary. A detailed explanation of this data flow is given in Chapter 6.
- Export information: This includes sending alerts to external devices and generating reports. A detailed explanation of this data flow is given in Chapter 7.

Chapter 3: Monitoring screens

Chapter highlights

- Dashboard screen
- Model data screen
- Charts
- Events and alarms
- Density table and density views
- Rules screen
- Log file

Each screen described in this chapter is accessible using the toolbar buttons at the top of the main screen.

3.1 Dashboard

Clicking the left button on the buttons panel activates the dashboard. Figure 2 shows a typical image of the dashboard.

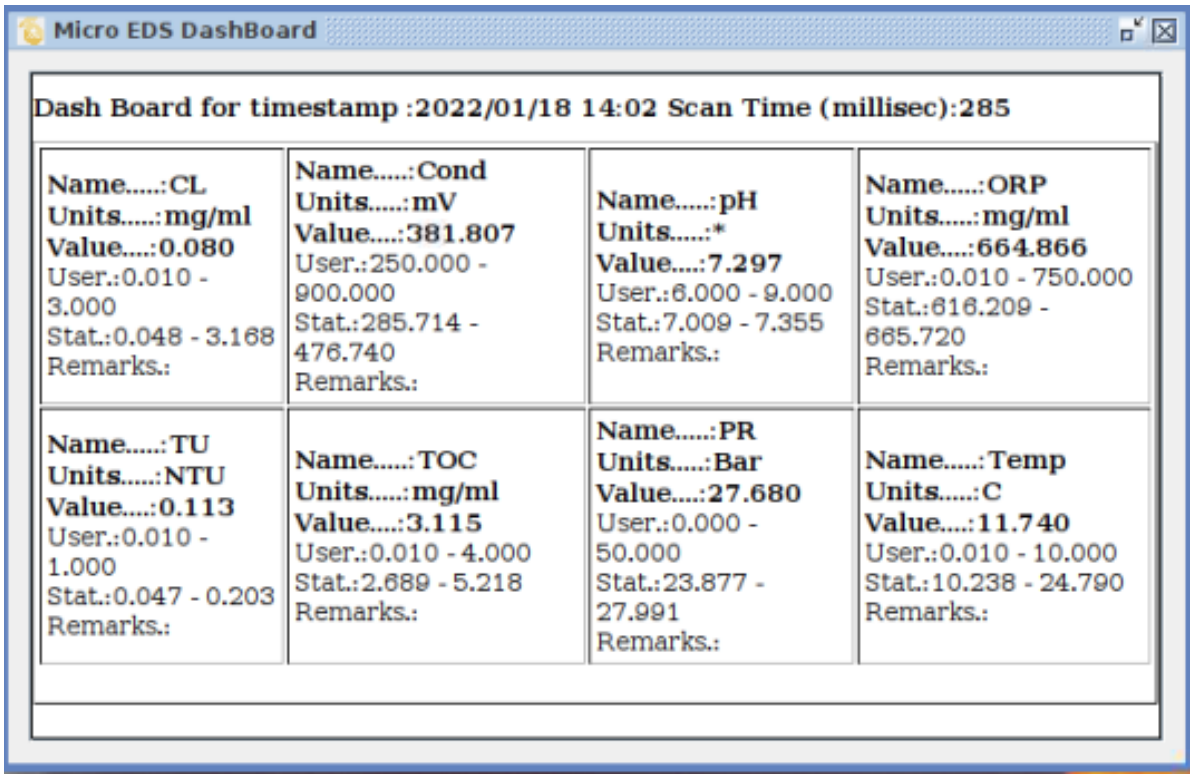


Figure 2: Dashboard screen

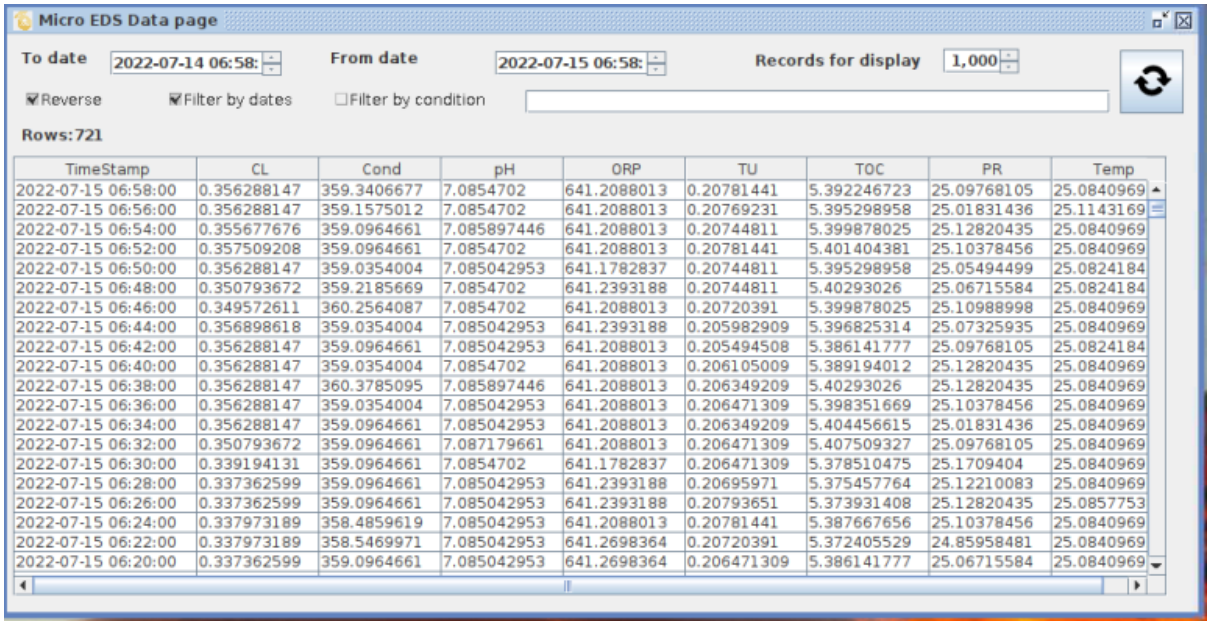
The dashboard displays the last values for each of the model's variables. Each box contains the following information: name, units, last value recorded from the raw data stream, user, and statistical limits.

At the top of the screen, the system displays the last time stamp processed and the scan time, representing the amount of time needed for this process. For example, Figure 2 shows that to process the data recorded at 2022/01/18 at 14:02, 285 ms was needed.

If the last value of one of the variables is outside of the statistical limits, its name will be highlighted in yellow in the background. If the last value violates the user's limits, the background colour will be red. If the variable is not processed (for example, because it has been disabled by the user), the background colour will be grey.

3.2 Data view board

Clicking the button second from the left on the buttons panel activates the data view. Figure 2 shows a typical image of the dashboard.



TimeStamp	CL	Cond	pH	ORP	TU	TOC	PR	Temp
2022-07-15 06:58:00	0.356288147	359.3406677	7.0854702	641.2088013	0.20781441	5.392246723	25.09768105	25.0840969
2022-07-15 06:56:00	0.356288147	359.1575012	7.0854702	641.2088013	0.20769231	5.395298958	25.01831436	25.1143169
2022-07-15 06:54:00	0.355677676	359.0964661	7.085897446	641.2088013	0.20744811	5.399878025	25.12820435	25.0840969
2022-07-15 06:52:00	0.357509208	359.0964661	7.0854702	641.2088013	0.20781441	5.401404381	25.10378456	25.0840969
2022-07-15 06:50:00	0.356288147	359.0354004	7.085042953	641.1782837	0.20744811	5.395298958	25.05494499	25.0824184
2022-07-15 06:48:00	0.350793672	359.2185669	7.0854702	641.2393188	0.20744811	5.40293026	25.06715584	25.0824184
2022-07-15 06:46:00	0.349572611	360.2564087	7.0854702	641.2088013	0.20720391	5.399878025	25.10988998	25.0840969
2022-07-15 06:44:00	0.356898618	359.0354004	7.085042953	641.2393188	0.205982909	5.396825314	25.07325935	25.0840969
2022-07-15 06:42:00	0.356288147	359.0964661	7.085042953	641.2088013	0.205494508	5.386141777	25.09768105	25.0824184
2022-07-15 06:40:00	0.356288147	359.0354004	7.0854702	641.2088013	0.206105009	5.389194012	25.12820435	25.0840969
2022-07-15 06:38:00	0.356288147	360.3785095	7.085897446	641.2088013	0.206349209	5.40293026	25.12820435	25.0840969
2022-07-15 06:36:00	0.356288147	359.0354004	7.085042953	641.2088013	0.206471309	5.398351669	25.10378456	25.0840969
2022-07-15 06:34:00	0.356288147	359.0964661	7.085042953	641.2088013	0.206349209	5.404456615	25.01831436	25.0840969
2022-07-15 06:32:00	0.350793672	359.0964661	7.087179661	641.2088013	0.206471309	5.407509327	25.09768105	25.0840969
2022-07-15 06:30:00	0.339194131	359.0964661	7.0854702	641.1782837	0.206471309	5.378510475	25.1709404	25.0840969
2022-07-15 06:28:00	0.337362599	359.0964661	7.085042953	641.2393188	0.20695971	5.375457764	25.12210083	25.0840969
2022-07-15 06:26:00	0.337362599	359.0964661	7.085042953	641.2393188	0.20793651	5.373931408	25.12820435	25.0857753
2022-07-15 06:24:00	0.337973189	358.4859619	7.085042953	641.2088013	0.20781441	5.387667656	25.10378456	25.0840969
2022-07-15 06:22:00	0.337973189	358.5469971	7.085042953	641.2698364	0.20720391	5.372405529	24.85958481	25.0840969
2022-07-15 06:20:00	0.337362599	359.0964661	7.085042953	641.2698364	0.206471309	5.386141777	25.06715584	25.0840969

Figure 3: Model data view

By default, the screen displays the last 1000 records from the last processed data, in reverse order. The dates at the top of the screen can also help in filtering the target records. A condition in SQL format (e.g. Field A > x and Field B <y) is also an option for filtering the data. For any valid selection, the refresh button at the top right side of the screen refreshes the screen.

3.3 Charts

Clicking the button third from the left in the buttons panel activates the chart view. Figure 4 shows a typical image of the chart view.

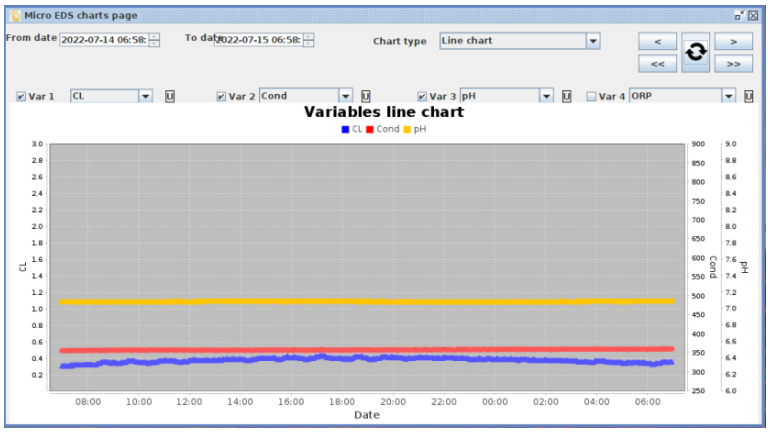


Figure 4: Chart view

This option can generate several types of chart views. The drop-down field labelled Chart Type enables the user to select the shape of the chart.

Line chart

Up to four different variables can be selected for the line chart window. The variables will be primary and secondary on both the right and left vertical axes. The buttons located to the left of each variable enable the user to select if the scale of the axis for this variable, as a user limit (U), statistical limit (S), or automatic limit (A), based on the actual data. The field data at the top of the screen enable the user to define the time range for the data retrieved. The panel at the top right side of the screen allows the time window to slide.

Histogram

The histogram option displays a frequency chart of the first variable. The number of bins is fixed at a value of 20. The date range can be selected using the upper left fields.

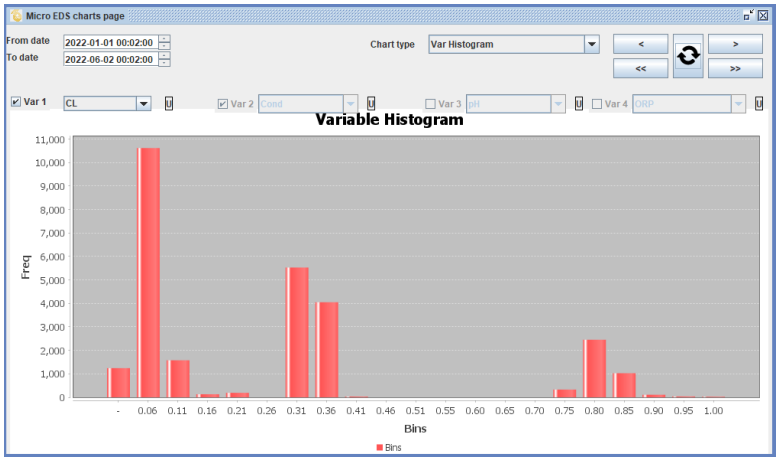


Figure 5: Histogram chart

Correlation chart

The correlation chart option displays an XY chart, with the first variable on the horizontal axis and the second on the vertical axis.

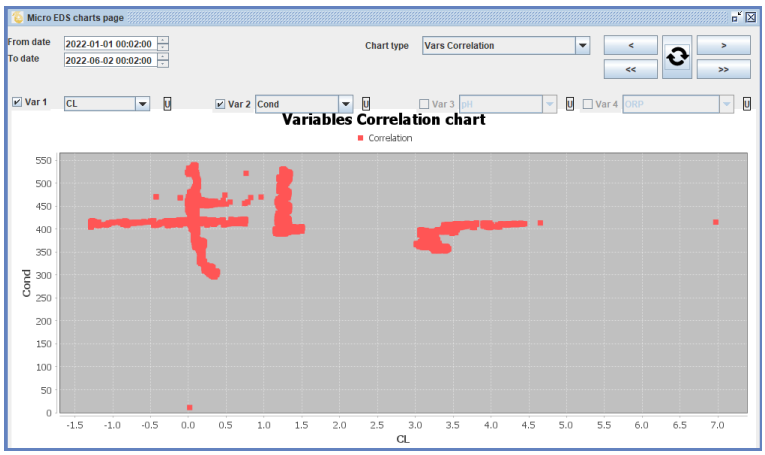
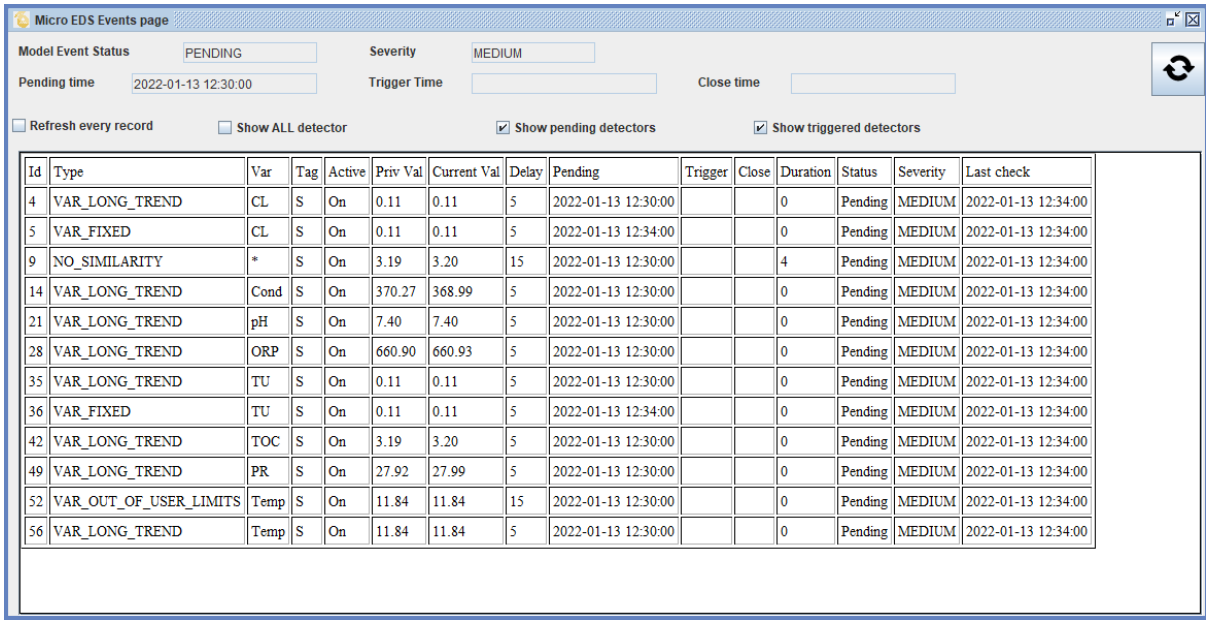


Figure 6: Correlation chart

3.4 Events and alarms

Clicking the button fourth from the left on the buttons panel activates the Current Events page. Figure 7 shows a typical image of the events page.



Id	Type	Var	Tag	Active	Priv Val	Current Val	Delay	Pending	Trigger	Close	Duration	Status	Severity	Last check
4	VAR_LONG_TREND	CL	S	On	0.11	0.11	5	2022-01-13 12:30:00			0	Pending	MEDIUM	2022-01-13 12:34:00
5	VAR_FIXED	CL	S	On	0.11	0.11	5	2022-01-13 12:34:00			0	Pending	MEDIUM	2022-01-13 12:34:00
9	NO_SIMILARITY	*	S	On	3.19	3.20	15	2022-01-13 12:30:00			4	Pending	MEDIUM	2022-01-13 12:34:00
14	VAR_LONG_TREND	Cond	S	On	370.27	368.99	5	2022-01-13 12:30:00			0	Pending	MEDIUM	2022-01-13 12:34:00
21	VAR_LONG_TREND	pH	S	On	7.40	7.40	5	2022-01-13 12:30:00			0	Pending	MEDIUM	2022-01-13 12:34:00
28	VAR_LONG_TREND	ORP	S	On	660.90	660.93	5	2022-01-13 12:30:00			0	Pending	MEDIUM	2022-01-13 12:34:00
35	VAR_LONG_TREND	TU	S	On	0.11	0.11	5	2022-01-13 12:30:00			0	Pending	MEDIUM	2022-01-13 12:34:00
36	VAR_FIXED	TU	S	On	0.11	0.11	5	2022-01-13 12:34:00			0	Pending	MEDIUM	2022-01-13 12:34:00
42	VAR_LONG_TREND	TOC	S	On	3.19	3.20	5	2022-01-13 12:30:00			0	Pending	MEDIUM	2022-01-13 12:34:00
49	VAR_LONG_TREND	PR	S	On	27.92	27.99	5	2022-01-13 12:30:00			0	Pending	MEDIUM	2022-01-13 12:34:00
52	VAR_OUT_OF_USER_LIMITS	Temp	S	On	11.84	11.84	15	2022-01-13 12:30:00			0	Pending	MEDIUM	2022-01-13 12:34:00
56	VAR_LONG_TREND	Temp	S	On	11.84	11.84	5	2022-01-13 12:30:00			0	Pending	MEDIUM	2022-01-13 12:34:00

Figure 7: Events page

This page displays only events which are currently active. The display of historical events is covered later in this manual.

At the top of the screen, the system displays the current status of the event (Pending or Triggered), the severity of the events, and the pending, triggering, and closing time stamps. Below the time stamps, the system displays four different switches.

Refresh every record – This forces the screen to refresh with every data record processed.

Show ALL detectors – When checked, this forces the system to display non-activated detectors.

Show pending detectors – When checked, this forces the system to display detectors still waiting for the end of the triggering period.

Show triggered detectors – When checked, this forces the system to display triggered detectors only. The triggered detector is on if the trigger condition is on more than the wait time.

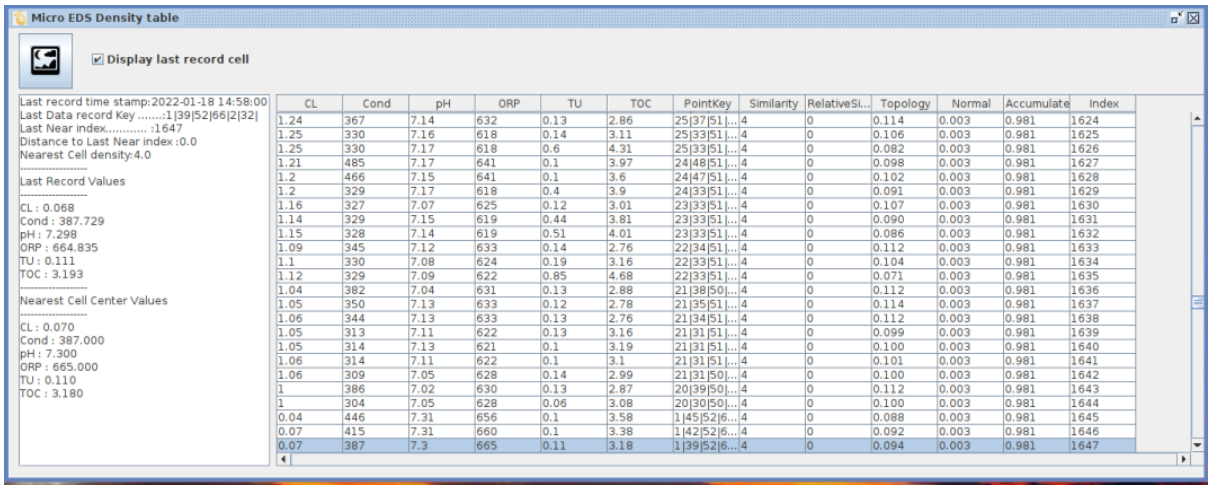
The events data table contains the following columns, which are constantly updated:

Table 4: Columns in the events table

Title	Content
ID	Index number of the detector
Type	Type of the detector
Var	Name of the variable of the detector
Tag	Identifier of the detector
Active	Indicates if the detector is active
Priv_Val	Previous value of the detector
Current_Val	Current value of the detector
Delay	Delay time (minutes) before triggering
Pending	Pending time for the event
Trigger	Trigger time of the event
Close	Close time of the event
Duration	Duration time of the current event
Status	Status of the event (pending or trigger)
Severity	Severity of the event
Last Check	When the detector was last evaluated

3.5 Density tables

Clicking the button fifth from the left on the buttons panel activates the Density Table view. Figure 8 shows a typical image of the density page.



CL	Cond	pH	ORP	TU	TOC	PointKey	Similarity	RelativeSi...	Topology	Normal	Accumulate	Index
1.24	367	7.14	632	0.13	2.86	25|37|51|...	4	0	0.114	0.003	0.981	1624
1.25	330	7.16	618	0.14	3.11	25|33|51|...	4	0	0.106	0.003	0.981	1625
1.25	330	7.17	618	0.6	4.31	25|33|51|...	4	0	0.082	0.003	0.981	1626
1.21	485	7.17	641	0.1	3.97	24|48|51|...	4	0	0.098	0.003	0.981	1627
1.2	466	7.15	641	0.1	3.6	24|47|51|...	4	0	0.102	0.003	0.981	1628
1.2	329	7.17	618	0.4	3.9	24|33|51|...	4	0	0.091	0.003	0.981	1629
1.16	327	7.07	625	0.12	3.01	23|33|51|...	4	0	0.107	0.003	0.981	1630
1.14	329	7.15	619	0.44	3.81	23|33|51|...	4	0	0.090	0.003	0.981	1631
1.15	328	7.14	619	0.51	4.01	23|33|51|...	4	0	0.086	0.003	0.981	1632
1.09	345	7.12	633	0.14	2.76	22|34|51|...	4	0	0.112	0.003	0.981	1633
1.1	330	7.08	624	0.19	3.16	22|33|51|...	4	0	0.104	0.003	0.981	1634
1.12	329	7.09	622	0.85	4.68	22|33|51|...	4	0	0.071	0.003	0.981	1635
1.04	382	7.04	631	0.13	2.88	21|38|50|...	4	0	0.112	0.003	0.981	1636
1.05	350	7.13	633	0.12	2.78	21|35|51|...	4	0	0.114	0.003	0.981	1637
1.06	344	7.13	633	0.13	2.76	21|34|51|...	4	0	0.112	0.003	0.981	1638
1.05	313	7.11	622	0.13	3.16	21|31|51|...	4	0	0.099	0.003	0.981	1639
1.05	314	7.13	621	0.1	3.19	21|31|51|...	4	0	0.100	0.003	0.981	1640
1.06	314	7.11	622	0.1	3.1	21|31|51|...	4	0	0.101	0.003	0.981	1641
1.06	309	7.05	628	0.14	2.99	21|31|50|...	4	0	0.100	0.003	0.981	1642
1	386	7.02	630	0.13	2.87	20|39|50|...	4	0	0.112	0.003	0.981	1643
1	304	7.05	628	0.06	3.08	20|30|50|...	4	0	0.100	0.003	0.981	1644
0.04	446	7.31	656	0.1	3.58	1|45|52|6...	4	0	0.088	0.003	0.981	1645
0.07	415	7.31	660	0.1	3.38	1|42|52|6...	4	0	0.092	0.003	0.981	1646
0.07	387	7.3	665	0.11	3.18	1|39|52|6...	4	0	0.094	0.003	0.981	1647

Figure 8: Density table

The records in the table represent discrete combinations of the historical data. Each combination has a centre value (for each variable) and additional properties.
The density table gives the user which combinations are common and which are rare. Rare combinations are likely to be suspected as bad ones.

Table 5: Columns in the density table

Title	Content
Variables	This is a list of variables depending the model structure. Each has a value.
Point key	This is a string that holds each variable's interval index according to the value; for example, if CL has a value of 0.2 and this value is located at the first interval of the CL, the index will be 1. Indexes are separated by a vertical line, |.
Relative similarity	This is the similarity normalised to a value between zero to one. A value of one is given to the combination record with the most occurrences in the history.

Topology	This is a value between zero and one which describes how "good" the combination is. A score of one means that all variables are at their optimum values.
Normal	This is the number of records with a similar value found in the historical values of the model.
Accumulated	This gives percentages for each record in the density table as they are accumulated from zero to one.
Index	This is the number of rows in the density table

If the check box marked "Display last record cell" is selected, the after each record is processed, the table will focus on the cell that contains this record.

The text area to the left of the screen displays data about the last record to be processed. This includes the identification of the record (e.g., timestamp), the cell in which the record is located, and the nearest neighbouring cell in case the previous cell is empty.

The button at the upper left corner of the screen activates the heat map. This screen enables the user to select two variables at a time and to display the density of records using a scatter plot. A green dot shows the location of the last record.

Figure 9 shows the heat map options. Heat map gives the user the option to display on a two variables dimensions, the density of combinations. It also gives the option to display three types of limits. Regulatory, statistical and engineering based limits. As can be seen from the example in figure 9, the heat map for CL and COND shows that current values of CL = 0.079 and COND = 387.179 (the green dot), is out of the engineering good zone but inside the user (regulatory) limits.
It should be noted that the heat map is updated on line with the latest value reported to the system.

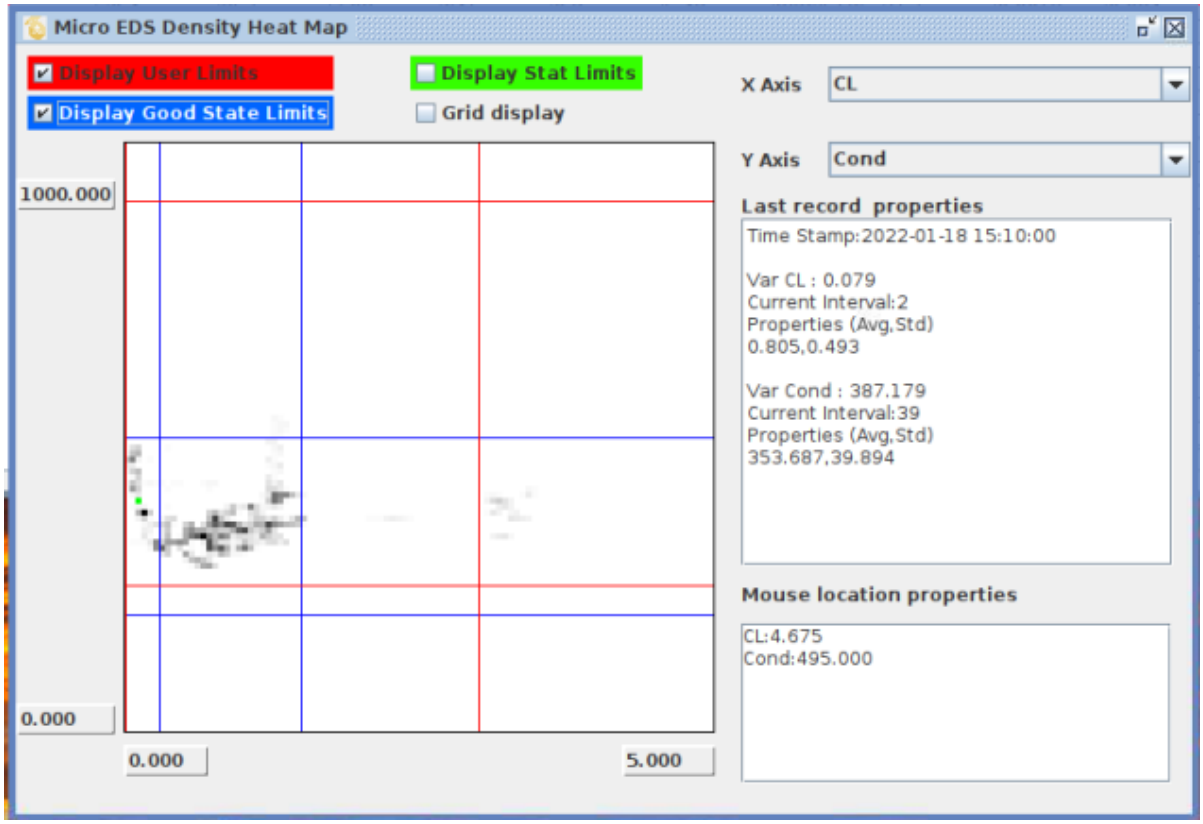


Figure 9: Density heat map

The four checkboxes at the top of the screen display horizontal and vertical lines indicating the user limits, statistical limits, good state limits and grid lines. The location of the mouse is also tracked at the bottom of the screen.

3.6 Rules

Clicking the button sixth from the left on the buttons panel activates the Rules Status page. Figure 10 shows an image of this page.

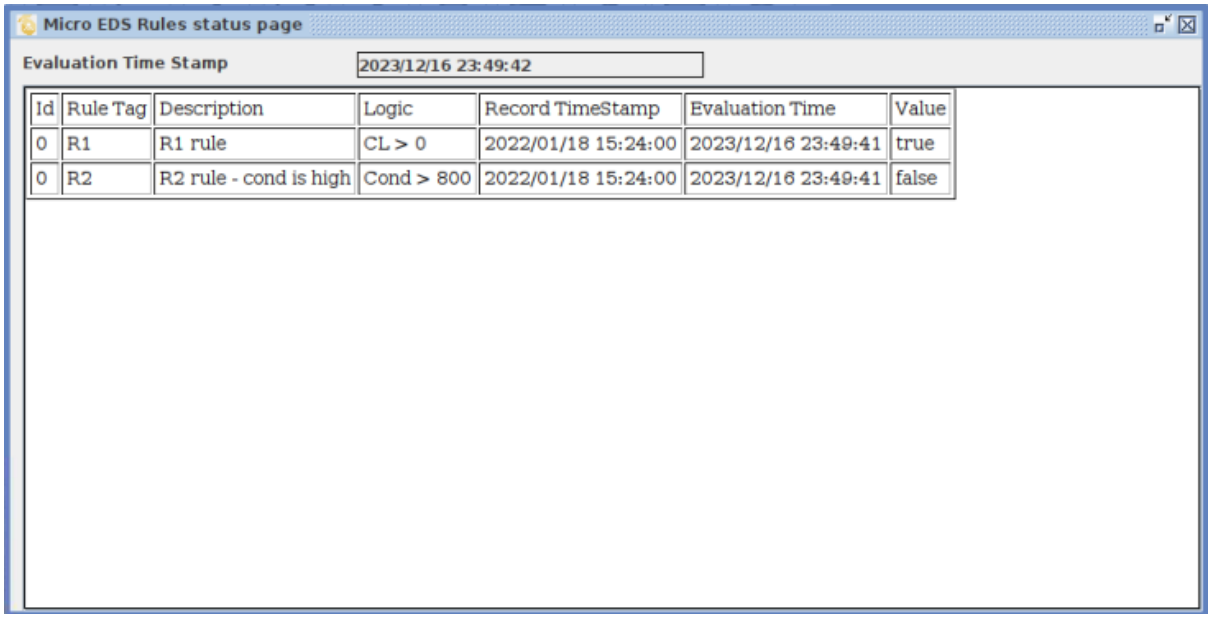


Figure 10: Rules status

The screen displays all of the rules defined in the system, together with the logic used to solve the rule. It also displays the record time stamp related to the last time the rules were evaluated, and the time stamp at which this evaluation was done. The last column shows the result of the evaluation.

Note that rules are used to activate and deactivate detectors. Rules are also used to solve the logic of rule-based detectors.

3.7 Log file view

Clicking the button seventh from the left on the buttons panel activates the Log File screen. Figure 11 shows an image of the log file status screen.

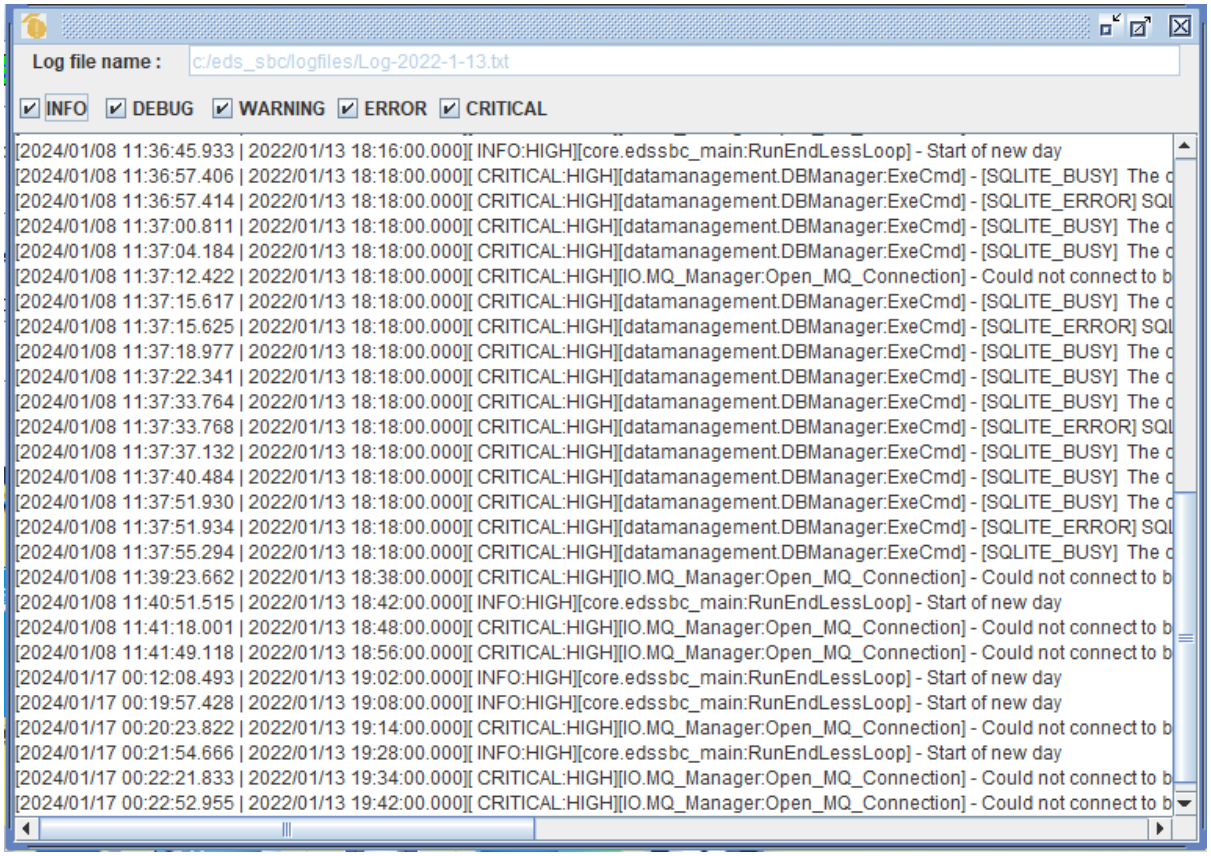


Figure 11: Log file screen

Each message in the log file has a timestamp, severity and message. The checkboxes at the top can be used to filter the messages based on their severity.

Chapter 4: Model handling

This chapter explains how to make changes to the MicroEDS model. It is assumed that the demo database is being used.

Chapter highlights

- Define variables
- Define detectors
- Define rules
- Define parameters
- Monitor versions
- Log files

4.1 Definition of variables

In order to change the model definition, the model must be in the Pause state. The model state can be changed from Run to Pause (and vice versa) using the two buttons in the upper toolbar, second and third from the right. Once the model has been stopped, the background colour of the real-time clock turns to grey.

Figure 12: Model in the paused state

When a model is in the Pause state, the first menu item under the model menu, 37abelled “Vars”, can be selected in enabled mode, as displayed in Figure 13.

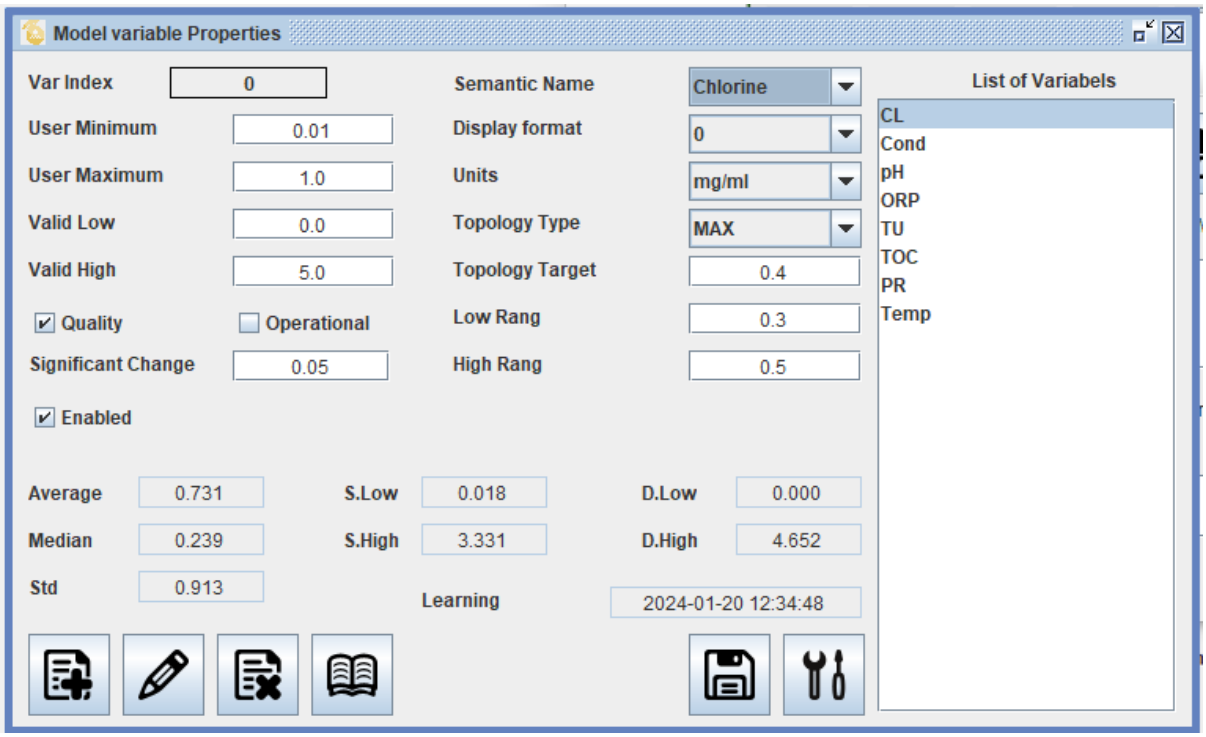


Figure 13: Definition of variables

Please note that if the model is in the Run mode, the fields in this form are disabled.

In order to display the properties of a selected variable, its name is selected from the list on the right-hand side of the screen. The buttons at the bottom of the screen enable the following actions.

Table 6: Buttons on the variables screen

Icon	Functionality
	Create a new empty variable
	Update currently selected variable properties, as displayed on the screen, into the memory of the model
	Delete the currently displayed variable from the model
	View statistics of the selected variable
	Save the model definition to the memory repository
	Change the name of the selected variable

When the variable properties are displayed, the user can edit them.

Table 7: Variable fields

Field	Read only	Description
Var Index	Yes	Index of the variable in the model (0-15)
Semantic Name	Drop down	Semantic name of the variable
User Minimum	No	Minimum value before alerting
User Maximum	No	Maximum value before alerting
Valid Low	No	Minimum valid value
Valid High	No	Maximum valid value
Display Format	Drop down	Format for displaying the variable
Units	Drop down	Physical units
Topology Type	Drop down	Shape of the curve describing the optimal value
Topology Target	No	Optimal value

Low Range	No	Minimum value for good range
High rang	No	Maximum value for good range
Quality	Yes/No	Variable is a quality measurement
Operational	Yes/No	Variable is an operational measurement
Enabled	Yes/No	Variable is used for processing data
Average	Yes	Calculated
Median	Yes	Calculated
STD	Yes	Calculated
S. Low	Yes	Statistical low
S. High	Yes	Statistical high
D. Low	Yes	Data low
D. High	Yes	Data high
Learning	Yes	Last date of learning

Once all fields have been updated, the user can click on the second button from the left to update these values in the variable object in the model memory. When all variables are updated, the fifth button from the left is clicked to store the variable definition in the model repository.
In order to activate the change, save the model and change its state to Run.

4.2 Detectors

Detectors are the heart of the EDS system. Each type of detector performs a specific check: if this ends with an alarm, an event is triggered. A detector is attached to a variable (or set of variables). The detectors setup screen is activated by selecting the second item from the model menu. In the same way as for the variables setup, the system must be in a paused state.

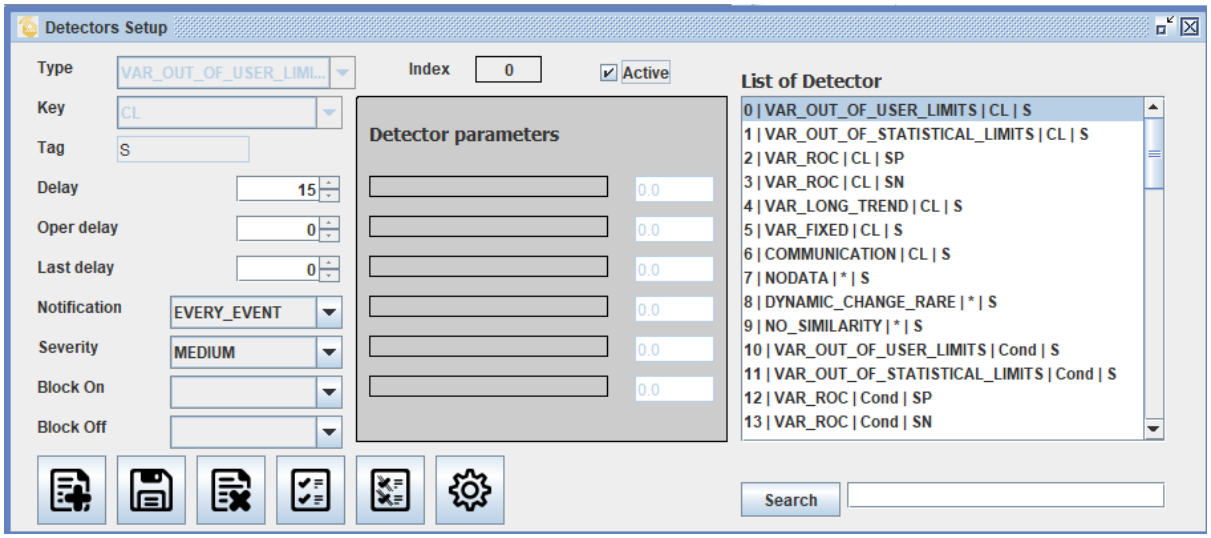
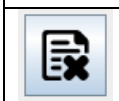


Figure 14: Detectors setup screen

Table 8 shows the actions offered by this screen.

Table 8: Buttons on the variables screen

Icon	Functionality
	Create a new empty detector. The user will be asked to select the detector type, variable name, and tag. The tag is a string that enables the user to set several detectors of the same type to the same variable, each with a different setup.
	Display the setup of the selected detector from the list on the right-hand side of the screen for editing.
	Delete the selected detector.
	Activate all detectors. When a detector is activated, it is processed during a data scan.

	Deactivate all detectors.
	Automatically generate detectors for all variables.

Table 7 shows the main fields for a single detector.

Table 8: Detector fields

Field	Description
Delay	How long (in minutes) the detector should be in the On state before it triggers an event.
Oper delay	How long the detector should be disabled after the operational change. An operational change is a situation in which an operational variable changes significantly.
Last delay	Minimum time (in minutes) for delaying a new event after closing the last event.
Notification	How often the event should be reported. Options are: • Each time an event is triggered • Once per hour • Once per day • Never
Block On Rule	Rule name used to filter the event when the rule is On.
Block Off Rule	Rule name to filter the event when the rule is Off.
Detector parameters	Parameters P1 to P6. Enable to set parameters for each detector type. For more details see the "Set Up Detectors document" from our web site.
Search	Search for a specific detector based on a text pattern.

4.3 Rules

Rules are used for two purposes:

- Filtering detectors. Figure 15 shows the rules setup screen.
- As logic for Rule based detectors.

Figure 15 shows the rules setup screen.

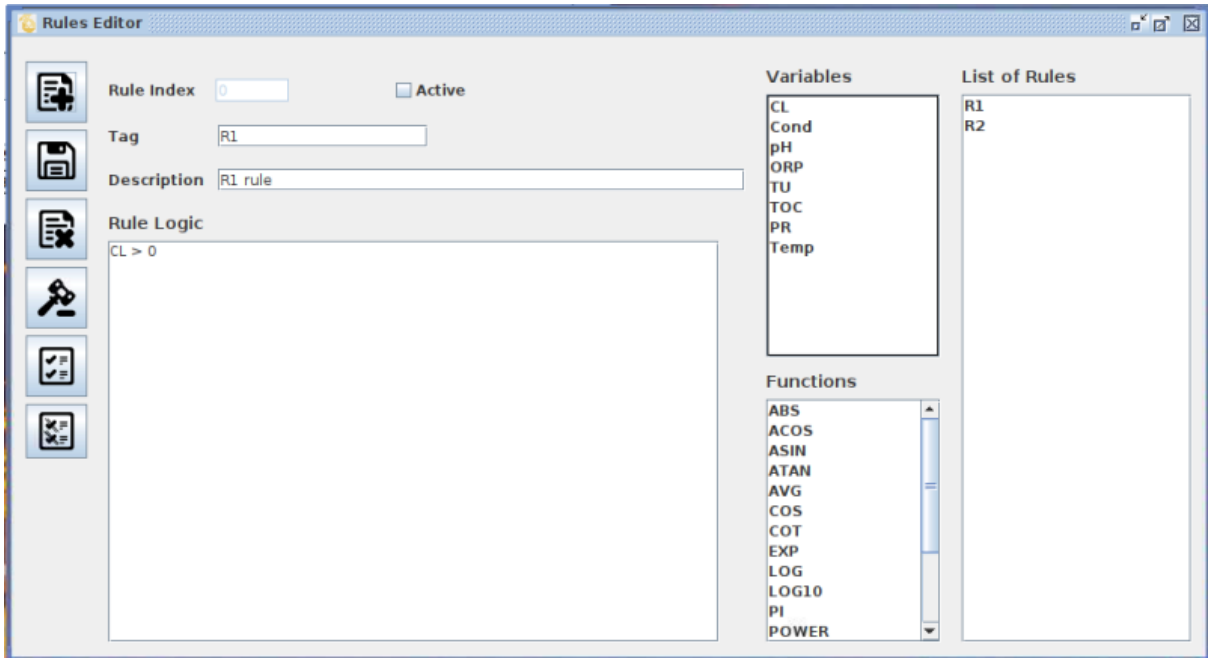


Figure 15: Rules setup

Table 9 summarises the basic functionality of the screen buttons.

Table 9: Rules screen buttons

Icon	Functionality
	Create a new empty rule
	Save the rule definition to the model definition
	Delete the selected rule

	Test the rule with model data
	Activate all rules
	Deactivate all rules

To edit a rule, double-click on the list of variables or functions and insert the proper string in the cursor location.
The list on the right contains tags for all defined rules. Clicking on an item from the list will display its properties, which can be edited in the field in the main screen.

4.4 Parameters

The MicroEDS model has a table of parameters, as shown in Figure 16, and this can be accessed from the model menu.

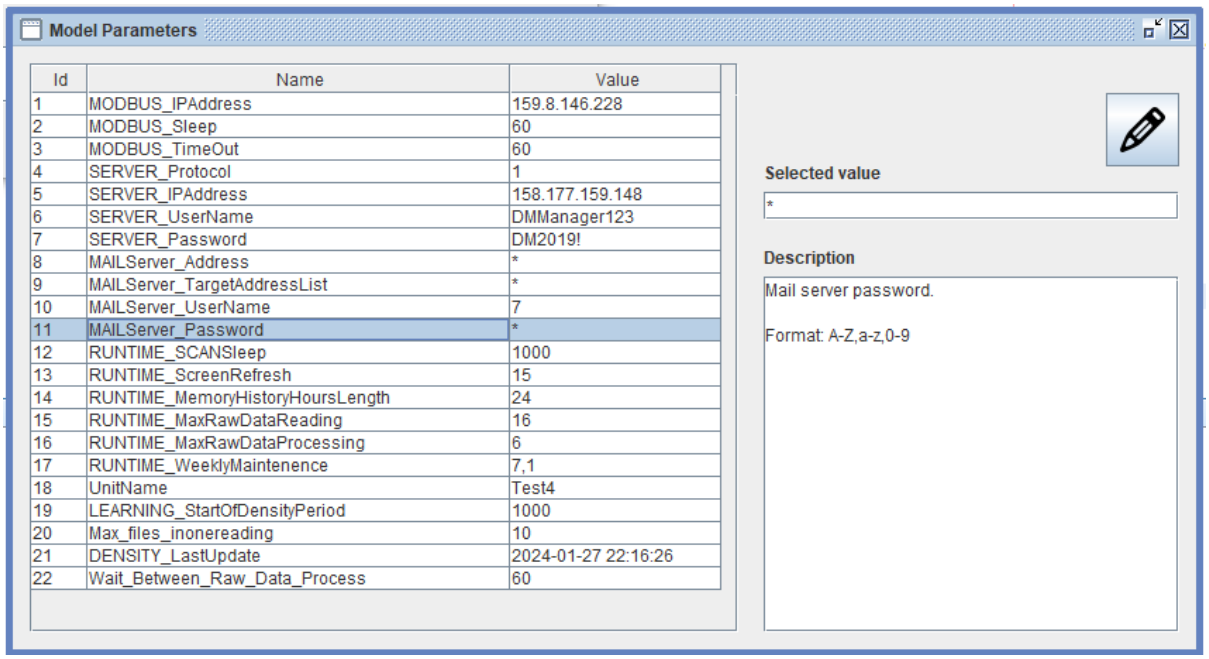


Figure 16: Parameters screen

The list of parameters is fixed, and the user is only able to update the value of each parameter. When a line is clicked, the value of that parameter is presented in the selected value field. An explanation of the parameter is shown in the description field. To update the parameter value, the user clicks on the button to the upper right of the screen. Table 10 gives a short explanation of each parameter.

Table 10: Parameter fields

Field	Description
MODBUS_IPAddress	IP address of data source for Modbus
MODBUS_Sleep	Sleep time between reading from Modbus
MODBUS_TimeOut	Time out for no answer from Modbus
SERVER_Protocol	Protocol for communication with server
SERVER_IPAddress	IP address of the server
SERVER_UserName	User name for server authentication
SERVER_Password	Password for server authentication
MAILServer_Address	Mail server address
MAILServer_TargetAddressList	Mail address target list
MAILServer_UserName	Mail user name
MAILServer_Password	Mail password
RUNTIME_SCANSleep	Sleep between scans at run time

RUNTIME_ScreenRefresh	Refresh time for the screen
RUNTIME_MemoryHistoryHoursLength	Memory history for lag calculation
RUNTIME_MaxRawDataReading	Max. no. of raw records read in one scan
RUNTIME_MaxRawDataProcessing	Max. no. of raw records processed in one scan
RUNTIME_WeeklyMaintenence	Time for weekly maintenance (day, hour)
UnitName	Name of the unit
LEARNING_StartOfDensityPeriod	Start date for learning from historical data
Max_files_inonereading	Max. no. of file readings of raw data in one scan
DENSITY_LastUpdate	Last timestamp for the density table update
Wait_Between_Raw_Data_Process	Wait in seconds between raw data processes
LOAD_MODEL_FROM_FILE	Load model from file rather than from database

When a parameter has been updated, the new model must be saved to the database.

4.5 Versions

A new version of the model is saved to the database each time a save operation is performed. The Versions screen lets the user browse the list of historical model versions and switch between versions.

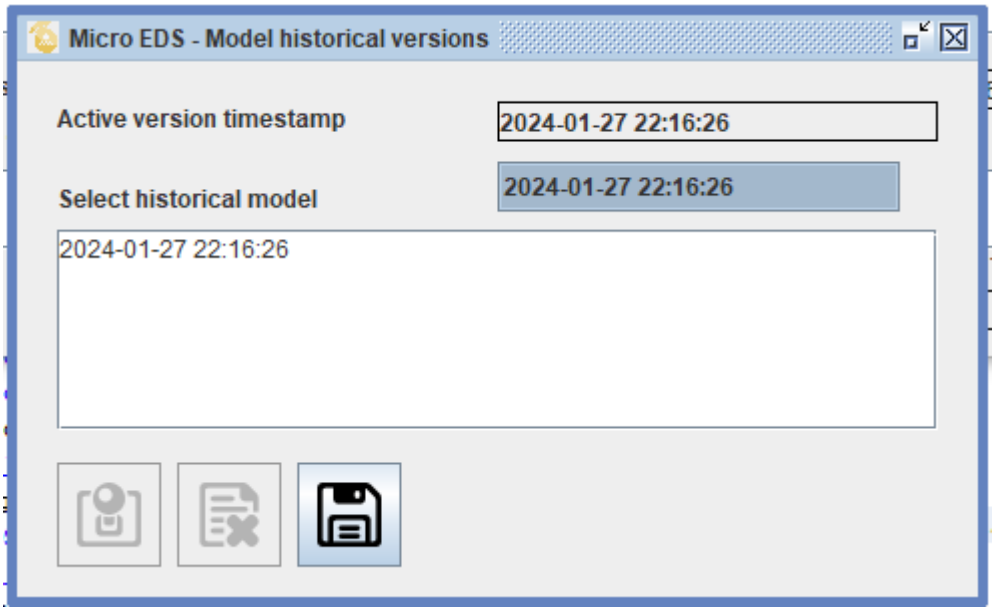


Figure 17: Versions screen

The Active Version timestamp shows the time stamp of the version that is currently running.

Table 11: Version screen buttons

Icon	Functionality
	Set the selected version as the active version (switching from the running version to the selected version will be activated after system boot)
	Delete the selected version
	Save the selected version as an external XML file

4.6 Validation log

Each time the model switches from Pause to Run, a validation log is created. The results of the validation test are located in the following directories:

- Windows: c:/eds_sbc/reports/validation/
- Linux : /home/pi/eds_sbc/reports/validation/

Chapter 5: Data handling

Chapter highlights

This chapter includes the following sub-sections:

- Templates
- Restructuring
- Importing
- Creating a DB
- Resetting the history
- Backing up the DB

5.1 Templates

The template menu enables the loading of a model definition from a CSV file. As can be seen from the explanation text displayed on the screen, the file should have a specific structure and should be located in a specific directory.

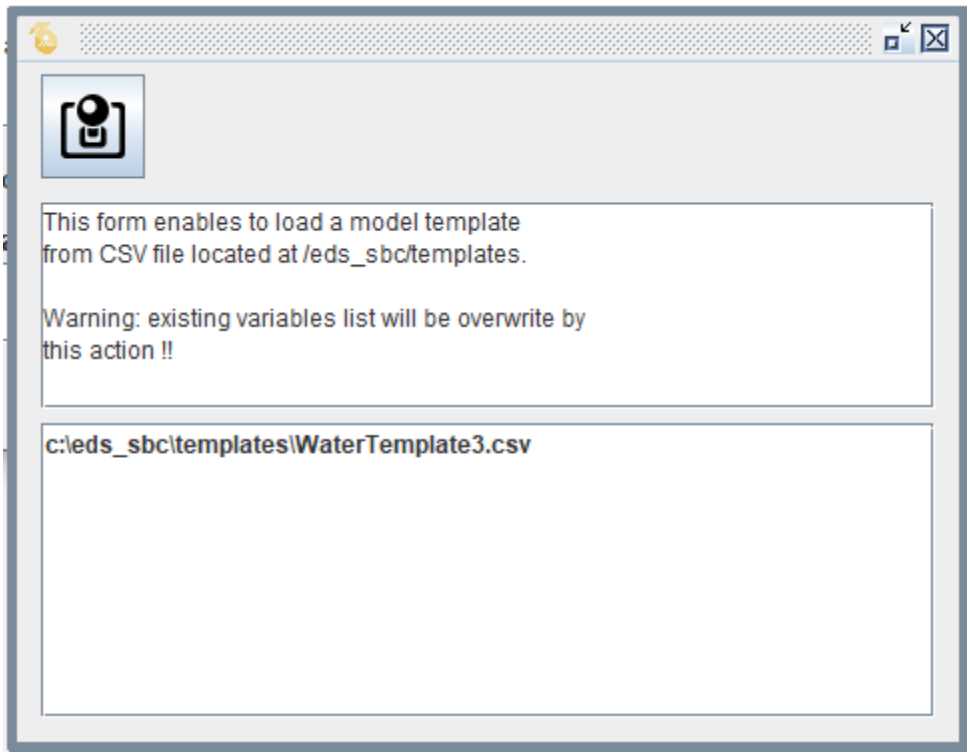


Figure 18: Template screen

All files located in the target directory will be displayed at the bottom of the screen. In order to load the template, the user must ensures the model is not in Run mode. Select the file and click on the button at the upper left of the screen. Please note that the template content will overwrite any existing model definition. Figure 19 should be the template's structure.

Index	VarName	Userminir	UserMaxir	ValidLow	ValidHigh	Quality	Operation	DisplayFo	Units	Topology	Target	LowRang	HighRang	Change	Semantic
1	CL	0.01	1	0	5	1	0	0	mg/ml	MAX	0.4	0.3	0.5	0.05	Chlorine
2	Cond	250	500	0	1000	1	0	0	mg/ml	OPTIMUM	7	25	1000	10	Conductivity
3	pH	6	9	0	14	1	0	0	mg/ml	OPTIMUM	0.4	0.2	0.4	0.05	pH
4	ORP	0.01	750	0	1000	1	0	0	mg/ml	MIN	300	250	500	10	ORP
5	TU	0.01	1	0	5	1	0	0	NTU	MIN	0	0	0.5	0.05	Turbidity
6	TOC	0.01	5	0	100	1	0	0	mg/ml	MIN	0	0	4	0.1	TOC
7	PR	0	50	0	100	0	1	0	bar	RANG	30	10	40	5	Pressure
6	Temp	0.01	10	0	100	0	1	0	mg/ml	RANG	0.4	0.3	0.5	0.1	Temperature

Figure 19: Model template in an Excel file

Please note that loading a template will reset the content of the model.

5.2 Restructuring

The Restructure option is used when a new set of fields needs to be defined in the model data table. The new set may contain both old and new fields. The aim of this action is to align the list of fields in the model data table in the database with the list of fields as defined in the model table.

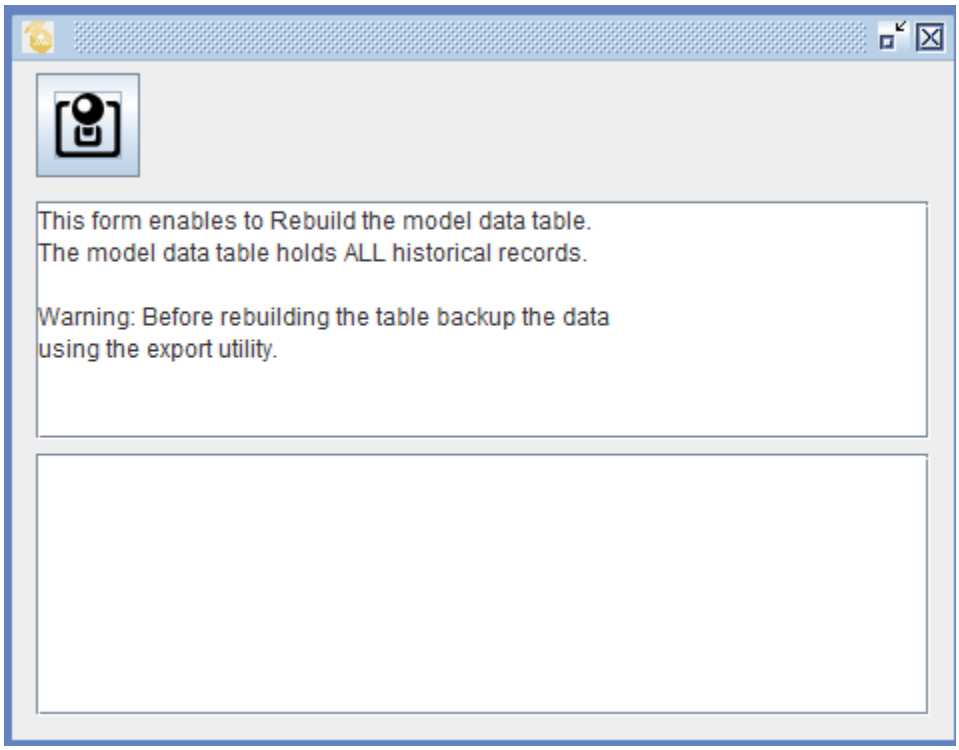


Figure 20: Restructure screen

Note that restructuring will reset all records in the model data table; before performing this action, the model data table should be exported to a file.

5.3 Importing

The Import option enables the user to import data from a CSV file into the model data table in the database. The CSV file containing the data should be located in the **csv_input** directory. When a file is located in this directory, it is displayed at the bottom of the screen, as shown in Figure 21.

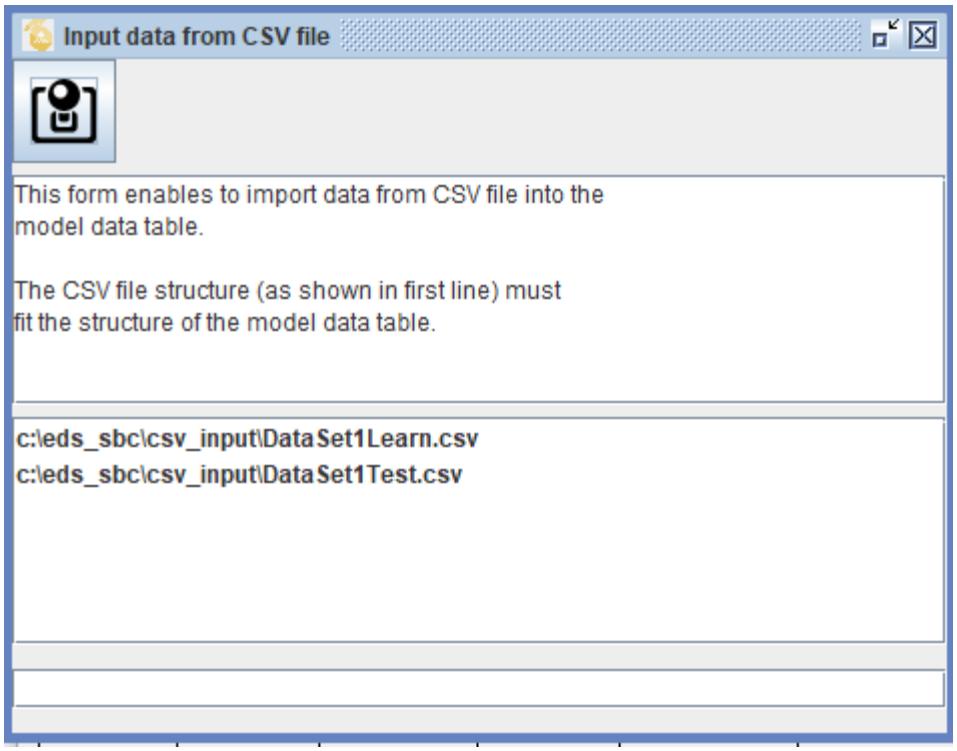


Figure 21: Import from CSV

To activate the Import procedure, the user must ensure that the model is not in Run mode. The structure of the model data must also match the structure of the CSV file. The first line of the CSV file should contain the fields, as shown in Figure 22.

Id	TimeStamp	CL	Cond	pH	ORP	TU	TOC	PR	Temp
1	1/1/2022 0:02	0.336752	299.1453	7.265385	669.6887	0.123932	2.773199	28.03419	14.34936
2	1/1/2022 0:04	0.336752	299.1453	7.264957	669.6887	0.124542	2.753358	27.97924	14.34936
3	1/1/2022 0:06	0.336142	300.1221	7.265385	669.6581	0.124176	2.777778	27.98535	14.35104
4	1/1/2022 0:08	0.336752	300.3663	7.267094	669.7192	0.123199	2.776252	27.97314	14.34936
5	1/1/2022 0:10	0.339805	299.1453	7.265385	669.6887	0.122589	2.794567	28.02198	14.34936
6	1/1/2022 0:12	0.337973	298.5348	7.265385	669.6887	0.122466	2.800672	27.99756	14.35104
7	1/1/2022 0:14	0.336752	298.718	7.265385	669.6887	0.122466	2.815934	28.02198	14.34936
8	1/1/2022 0:16	0.336752	297.3138	7.265385	669.7192	0.122222	2.803724	27.96703	14.35104
9	1/1/2022 0:18	0.348962	297.3748	7.265812	669.7192	0.122344	2.81746	28.01587	14.34936

Figure 22: CSV input file

5.4 Creating a database

The Create Database option enables the user to create an empty database. The new database will have the same structure as EDS_SBC.db.

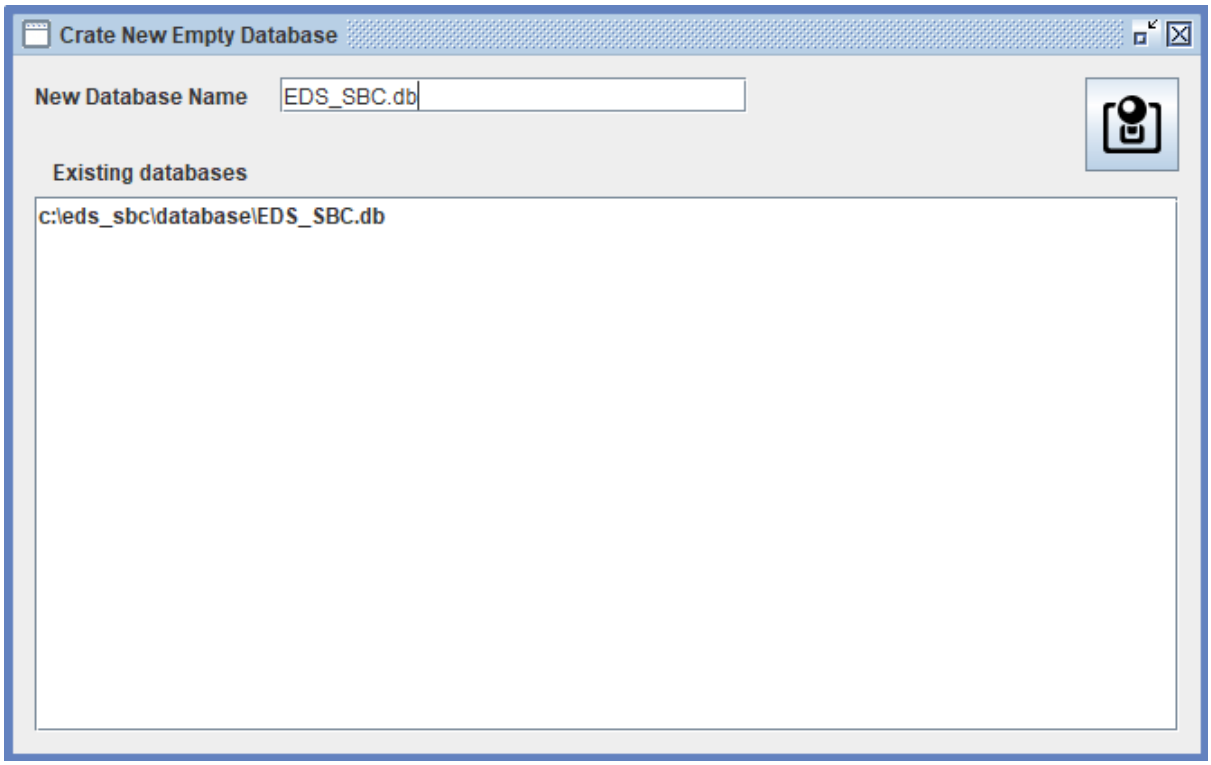


Figure 23: Create DB screen

The new database will be located in the /eds_sbc/database/ directory. In order to turn the new database into an active database, please change its name to EDS-SBC.db. Do not forget to back up the previous EDS_SVC.db beforehand !

5.5 Resetting the history

The Reset History option rewinds the clock of the model to a given timestamp. This option is only enabled when the model is in the Pause state.
Once the model returns to Run mode (after resetting), it will start to process data from the timestamp to which it was reset. Figure 24 shows the reset window.

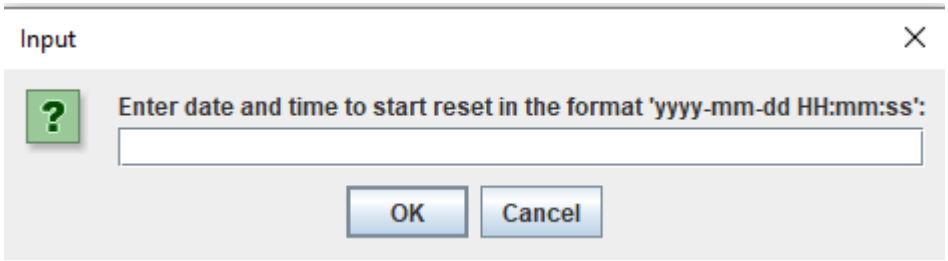


Figure 24: Reset History message

5.6 Backup database

The backup option enables the creation of a copy of the currently working database.

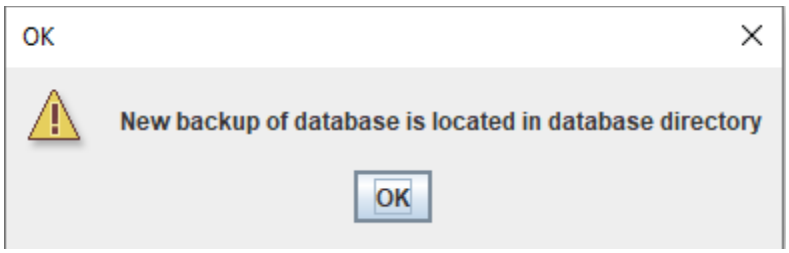


Figure 25: Create DB Backup message

The new backup will be located in the /database/ directory. A confirmation message (shown in Figure 25) will be displayed when the backup process is successfully completed.

Chapter 6: Importing real-time data

Chapter highlights

This chapter includes four methods for importing data to the MicroEDS at runtime.

- Non-pivoted CSV
- Modbus reading
- FTP injection (Will be available on version 1.1)

6.1 Non-pivoted CSV

Non-pivoted CSV input files have the following structure:

- Timestamp
- Variable name
- Variable value

The timestamp must be in the format **yyyy-MM-dd HH:mm:ss**. Variable names must be chose from those included in the model variables. The value must be numeric; in the case of a Boolean variable, zero is false, and one is true.
Figure 26 shows the setup screen for non-pivoted files.

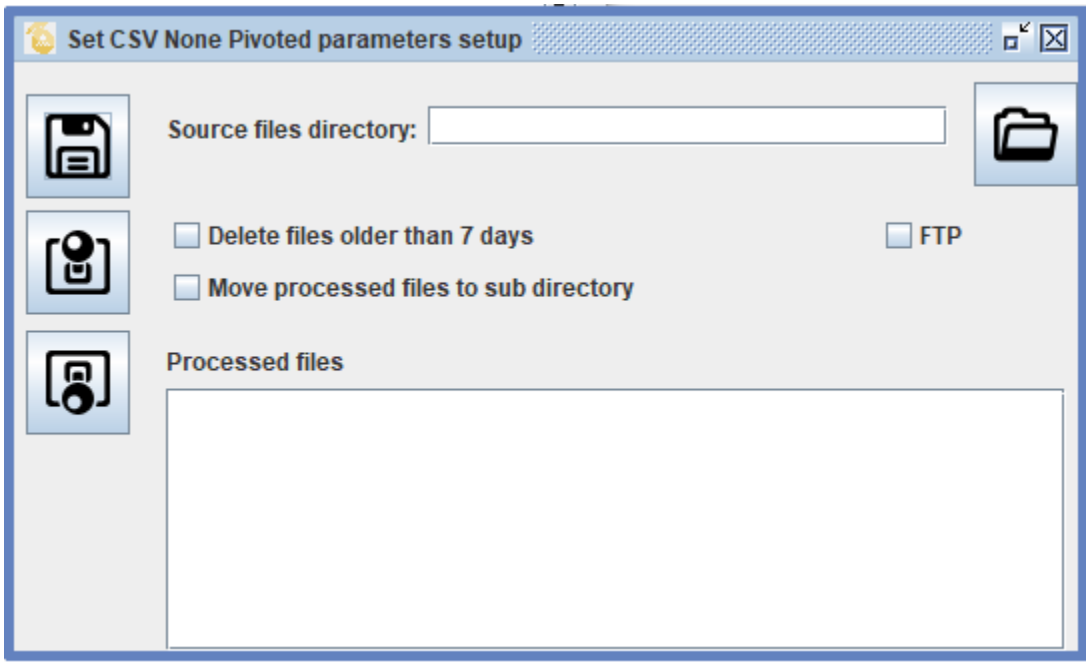


Figure 26: Non-pivoted CSV setup screen

The screen enables the user to select the directory for the data files. It also includes the option to move files to a sub-directory (labelled "Done"). Another check box offers the option of deleting files older than seven days.

The FTP check box indicates that the unit should accept CSV files via FTP. Checking this box will cause the unit to listen on the FTP port (22). Each line accepted via FTP should have the same structure (timestamp, var name, value). The unit will group values with records based on mutual timestamps; in other words, each time a new timestamp is introduced, a new record is started. If some of the variable values are

not updated for a given timestamp, the values from the previous timestamp will be copied.
Table 9 gives the details about watching one of the screen's buttons.

Table 9: Non-pivoted data input setup

Icon	Functionality
	Save the setup to the model definition
	Activate the setup
	Deactivate the setup

6.2 Modbus

The second option for reading data into the MicroEDS is to use the Modbus/FTP protocol. The current version of MicroEDS implements Modbus/FTP via port 502. The user needs to supply the address of the Modbus server (as shown in the second field of the screen).

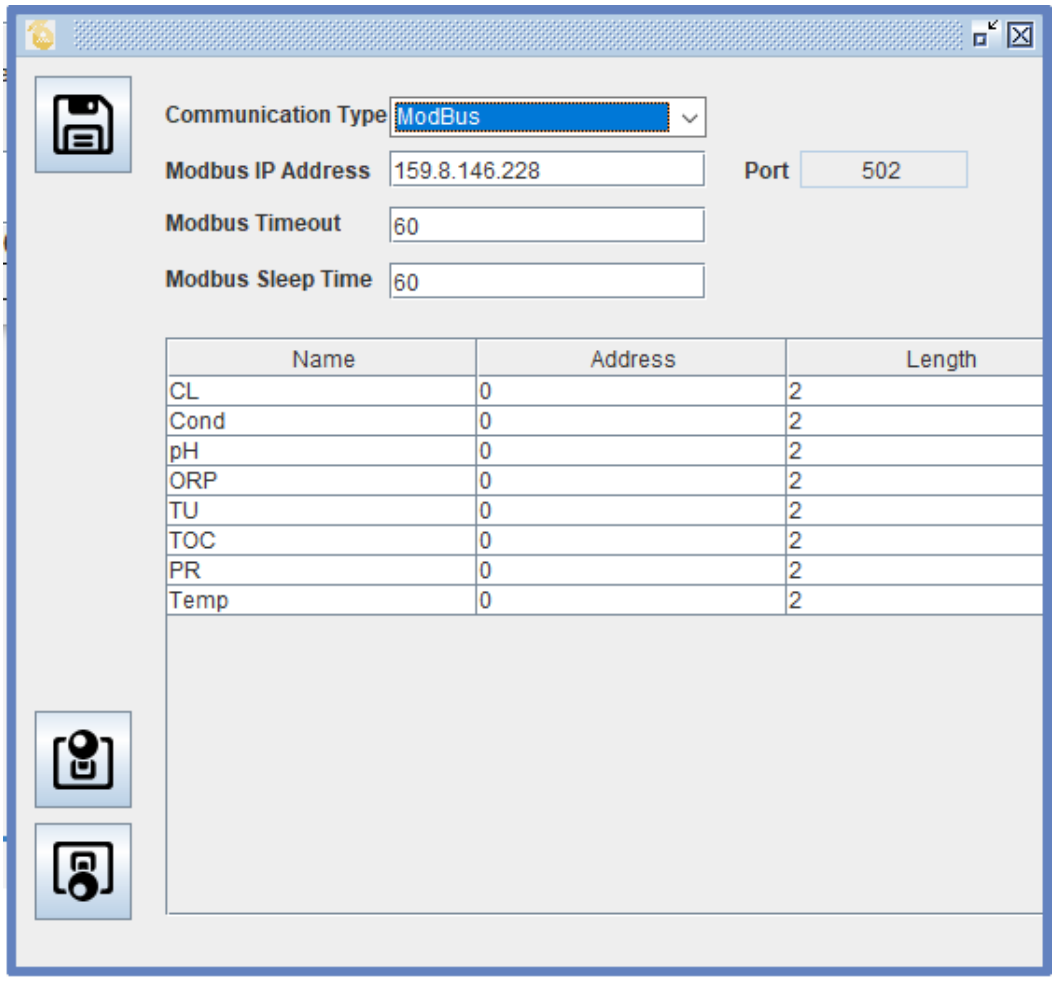


Figure 27: Modbus setup

The list of variables is automatically copied from the model definition. The user must supply the register's Modbus address, which is the source for each variable; for example, if CL should be read from register 40001, its address in the table will be 1.

Table 10 gives the details about watching one of the screen's buttons.

Table 10: Non-pivoted data input setup

Icon	Functionality
	Save the setup to model definition
	Activate the setup
	Deactivate the setup

Please note that the CSV input and the Modbus cannot be active at the same time: activating one of these deactivates the other, and vice versa.

Chapter 7: Data processing

The MicroEDS application has three working modes: Run, Pause, and Edit.

Run mode: The application listens for incoming data, processes the data, and sends notifications if needed. All screens are updated, and no editing activities are allowed.

Pause mode: The application listens for incoming data. All screens are updated, and no editing activities are allowed.

Edit mode: The user can edit the model's variables, detectors, or rules. When editing is complete, the user should save the new version of the model to the database.

The mode is indicated by the background colour of the time stamp, which is located at the upper left of the screen. Table 11 shows the colours used to represent the mode.

Table 10: Colours used to indicate mode

Colour	Mode
Green	Run mode
Gray	Pause mode
Blue	Edit mode
RED	Error mode
Black	No valid model

In Run mode, the unit performs the following activities:

1. Reading raw data
2. Solving rules
3. Running detectors
4. Updating the database
5. Sending notifications (if necessary)

The scan time indicated on the main screen represents the time it takes to complete the above activities.

In Pause mode, only raw data are read by updating the database with non-processed records.

In Edit mode, none of the above are performed.

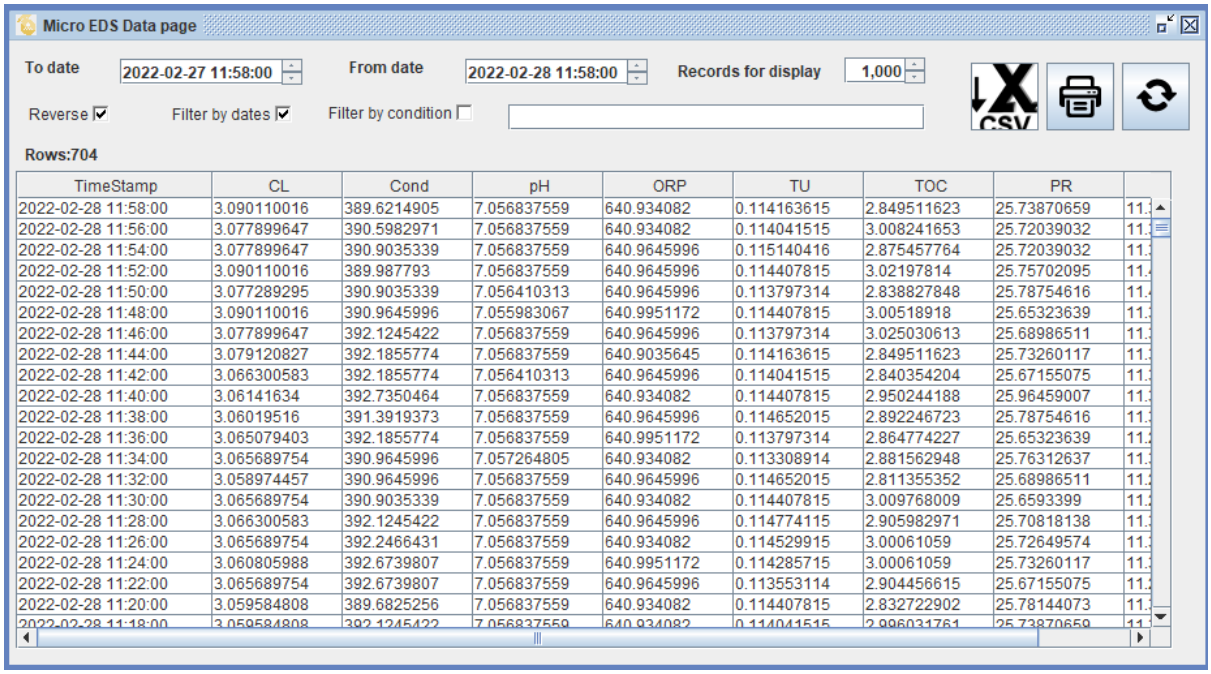
If errors occur in the Run mode, the relevant messages are shown in the log file.

Chapter 8: Exporting information

Data can be exported from MicroEDS using several methods.

8.1 Printing or saving as CSV

The two buttons at the right of the data page enable the user to print or save the data as a CSV file. Note that printing or saving refers to the actual presented dates, not the displayed records.



TimeStamp	CL	Cond	pH	ORP	TU	TOC	PR	
2022-02-28 11:58:00	3.090110016	389.6214905	7.056837559	640.934082	0.114163615	2.849511623	25.73870659	11.
2022-02-28 11:56:00	3.077899647	390.5982971	7.056837559	640.934082	0.114041515	3.008241653	25.72039032	11.
2022-02-28 11:54:00	3.077899647	390.9035339	7.056837559	640.9645996	0.115140416	2.875457764	25.72039032	11.
2022-02-28 11:52:00	3.090110016	389.987793	7.056837559	640.9645996	0.114407815	3.02197814	25.75702095	11.
2022-02-28 11:50:00	3.077289295	390.9035339	7.056410313	640.9645996	0.113797314	2.838827848	25.78754616	11.
2022-02-28 11:48:00	3.090110016	390.9645996	7.055983067	640.9951172	0.114407815	3.00518918	25.65323639	11.
2022-02-28 11:46:00	3.077899647	392.1245422	7.056837559	640.9645996	0.113797314	3.025030613	25.68986511	11.
2022-02-28 11:44:00	3.079120827	392.1855774	7.056837559	640.9035645	0.114163615	2.849511623	25.73260117	11.
2022-02-28 11:42:00	3.066300583	392.1855774	7.056410313	640.9645996	0.114041515	2.840354204	25.67155075	11.
2022-02-28 11:40:00	3.06141634	392.7350464	7.056837559	640.934082	0.114407815	2.950244188	25.96459007	11.
2022-02-28 11:38:00	3.06019516	391.3919373	7.056837559	640.9645996	0.114652015	2.892246723	25.78754616	11.
2022-02-28 11:36:00	3.065079403	392.1855774	7.056837559	640.9951172	0.113797314	2.864774227	25.65323639	11.
2022-02-28 11:34:00	3.065689754	390.9645996	7.057264805	640.934082	0.113308914	2.881562948	25.76312637	11.
2022-02-28 11:32:00	3.058974457	390.9645996	7.056837559	640.9645996	0.114652015	2.811355352	25.68986511	11.
2022-02-28 11:30:00	3.065689754	390.9035339	7.056837559	640.934082	0.114407815	3.009768009	25.6593399	11.
2022-02-28 11:28:00	3.066300583	392.1245422	7.056837559	640.9645996	0.114774115	2.905982971	25.70818138	11.
2022-02-28 11:26:00	3.065689754	392.2466431	7.056837559	640.934082	0.114529915	3.00061059	25.72649574	11.
2022-02-28 11:24:00	3.060805988	392.6739807	7.056837559	640.9951172	0.114285715	3.00061059	25.73260117	11.
2022-02-28 11:22:00	3.065689754	392.6739807	7.056837559	640.9645996	0.113553114	2.904456615	25.67155075	11.
2022-02-28 11:20:00	3.059584808	389.6825256	7.056837559	640.934082	0.114407815	2.832722902	25.78144073	11.
2022-02-28 11:18:00	3.059584808	392.1245422	7.056837559	640.934082	0.114041515	2.996031761	25.73870659	11.

8.2 Validation report

A validation process is performed each time the state of the model changes from Pause to Run. The results of the validation test are presented in three groups.

Critical test – Validation process failed
Warning test – These remarks did not prevent us from moving to Run mode. However, they must pay attention to the user.

Passed test – Test passed OK.

Figure 28 shows the validation report screen.

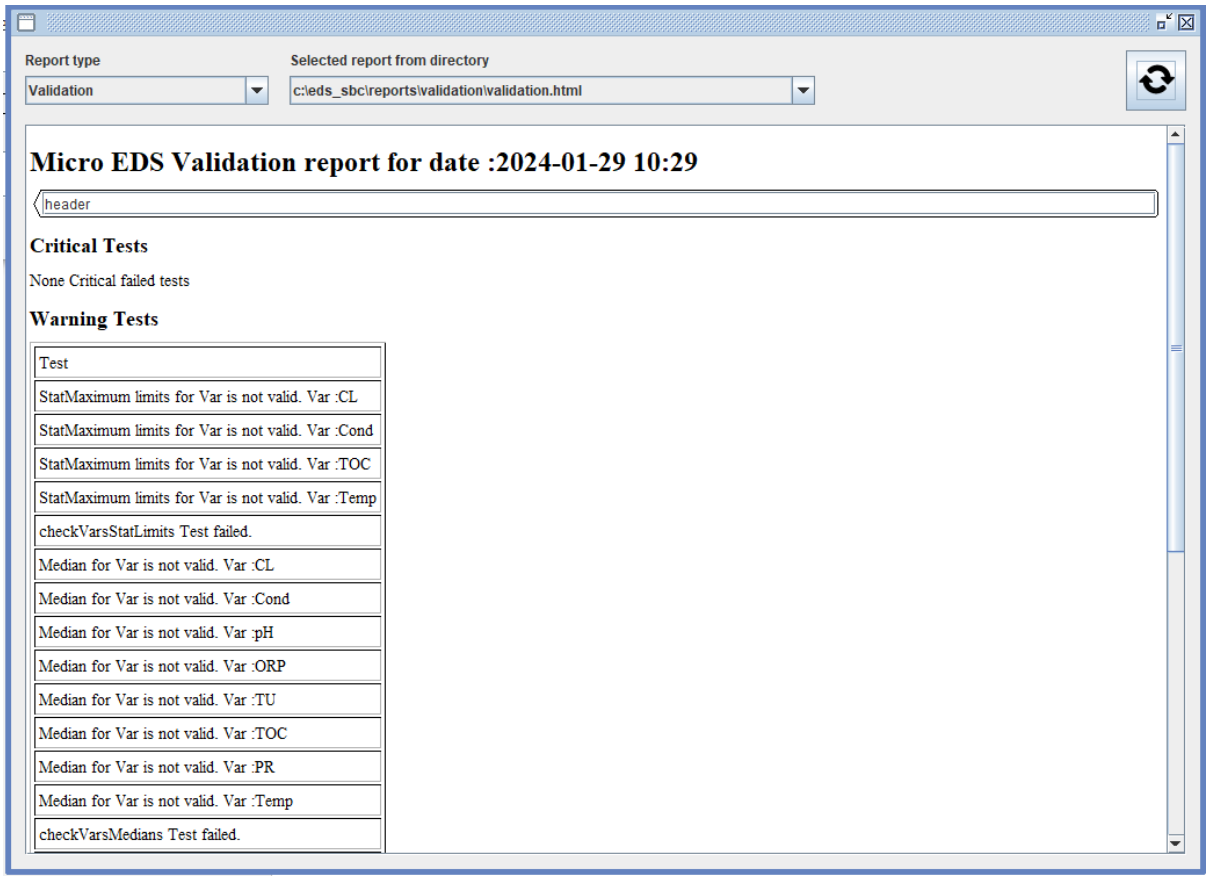


Figure 28: Validation report

8.3 Detector's age triggering history

The option marked Detector's Age Triggering History enables each detector to display the time distribution of the alarm, i.e., how many times the detector was in an alarm state for X minutes.

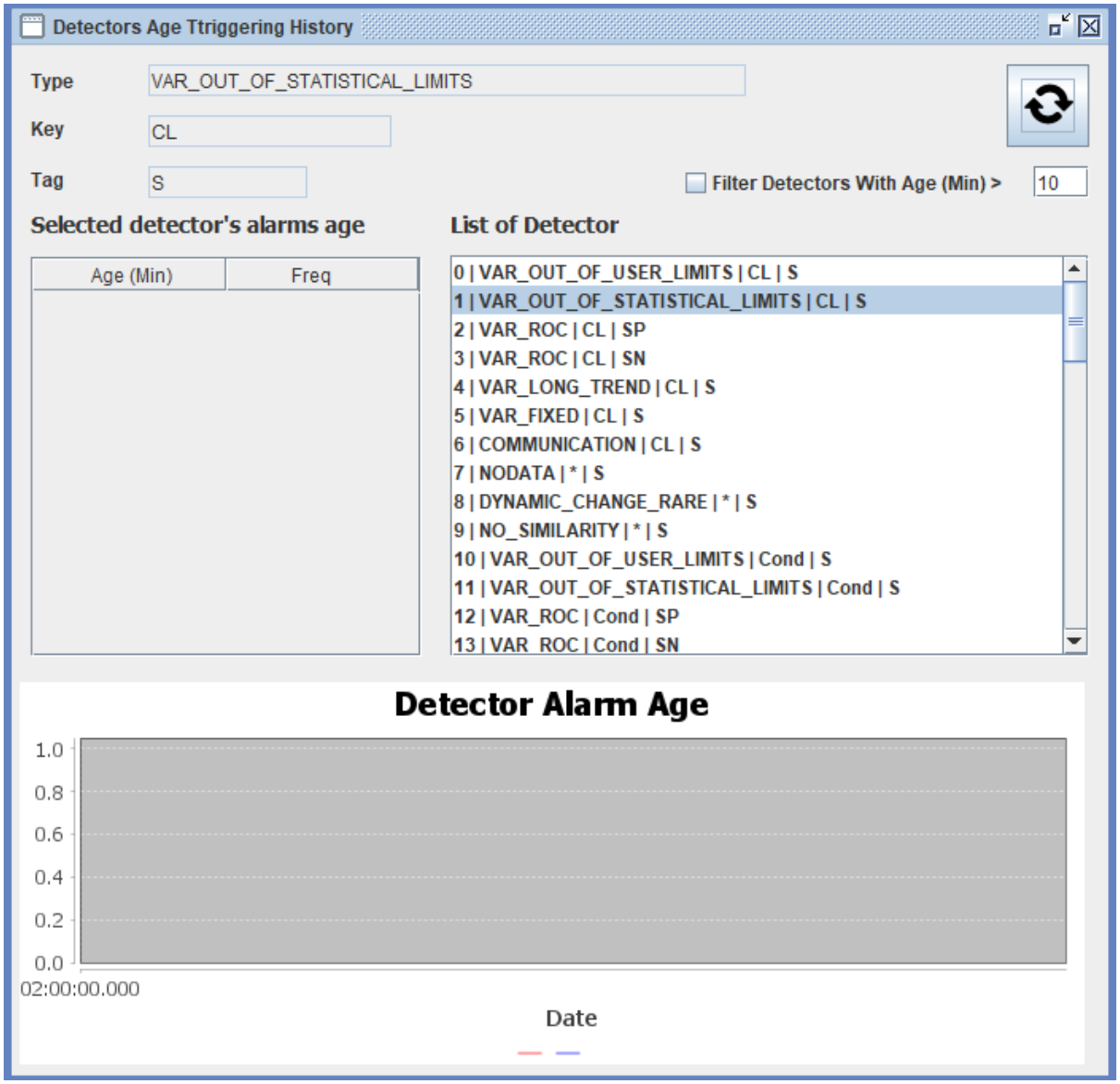


Figure 29: Detector age triggering

When the user clicks on a detector on the list, the alarm age data are displayed as both a table and a chart. Please note that alarms can be filtered by their length in minutes.

This screen can be used to set the delay time for each detector.

8.4 Historical events report

This option displays events for a given time window. Events are displayed in reverse order from the last (at the top) to the first. Figure 30 shows an example of this screen.

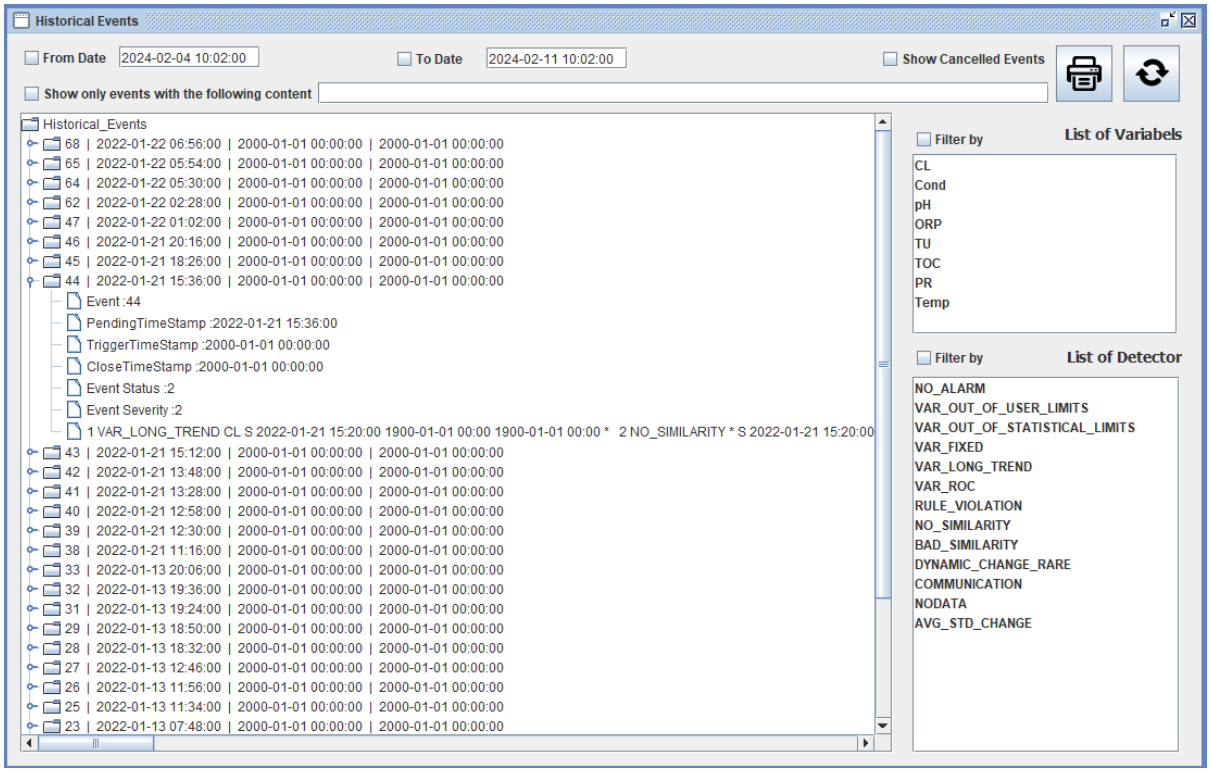


Figure 30: Historical events report

Events may be filtered by variable or by detector. The displayed data can be printed as a hard copy.

Chapter 9: Building and training a new model

The process of training a new model involves the following stages:

Step 1: Prepare a model template using a CSV file. The structure of the template file is given in Section 5.1 of this manual.

Step 2: Load the template into the model.

Step 3: Restructure the model fields as explained in Section 5.2.

Step 4: Load raw data as described in Section 5.3.

Step 5: Define the detectors (see Section 4.2) and rules (Section 4.3).

Step 6: Train the model. This activity is performed using the last sub-menu item. Note that training is possible only when the model is in the Pause state.

Once the model has been trained, go to Reports-> Validation to verify the results of the training procedure. If validation has succeeded, the model can be switched into the Run state.

The list of parameter values can also be reviewed to make any changes that are needed.

Chapter 10: Maintenance

The following activities are needed for normal, healthy long-term operation of MicroEDS. These operations refer to a situation in which MicroEDS is running on SBC hardware such as a Raspberry Pi.

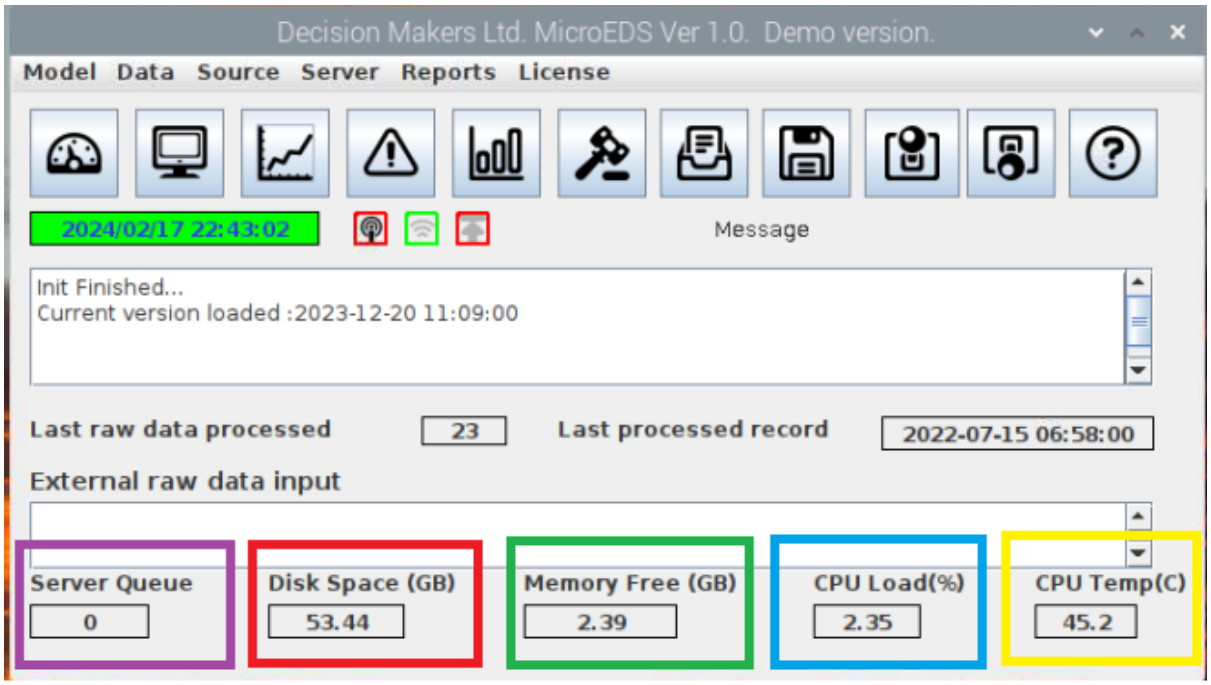


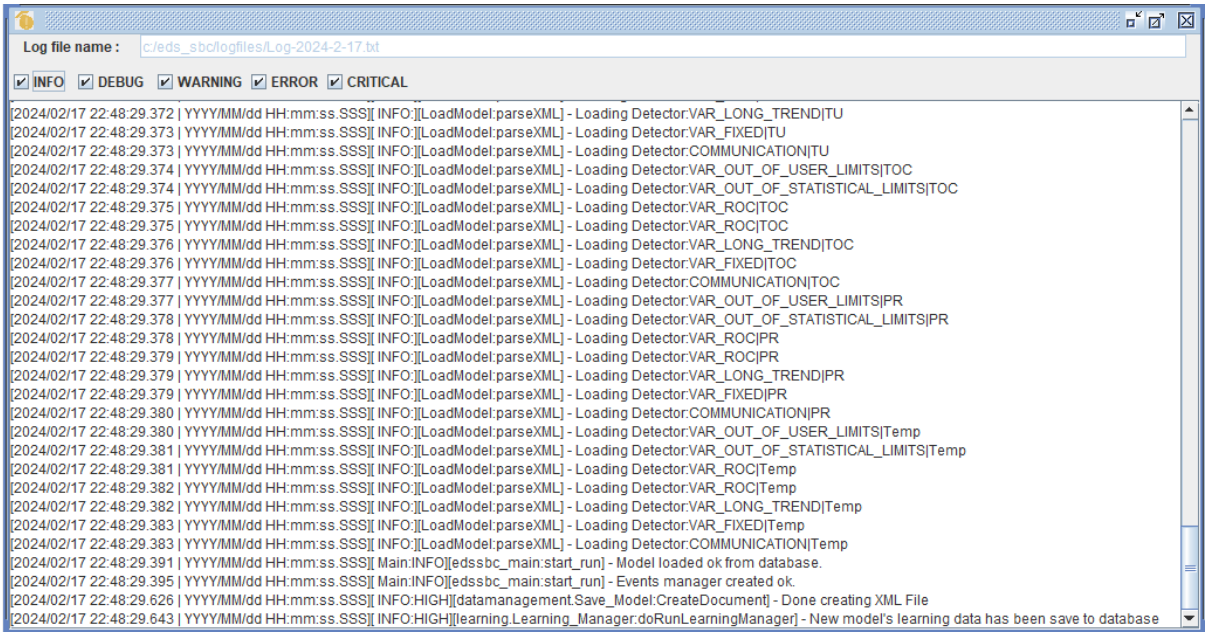
Figure 31: Health indicators

10.1 Visual health indicators

- Free space on the SD Card/disk (shown in red)
- Free amount of memory (shown in green)
- CPU load (shown in cyan)
- CPU temperature (shown in yellow)
- Unhandled messages in the server queue (shown in purple)

10.2 Monitoring the daily log files

Daily log are accumulated in the /home/pi/eds_sbc/logfiles/ directory.
Log files can be examined via the operating system or by clicking on the Log File Windows screen from the Log Files button.



Messages can be filtered by category, with the following options:
Info, Debug, Warning, Error, Critical.

If you purchased the support service for MicroEDS, our team will be happy to assist in solving the problem. To request this, please open a support ticket on our website.

Chapter 11: Commercial license

The version of MicroEDS that can be downloaded from our website is an evaluation version. It has full functionality, except that it stops functioning after three hours. In order to activate it, the user needs to reset the MicroEDS program.

Hence, a full examination can be made of this evaluation version, but it cannot be used for online or real-time purposes. In order to obtain a commercial real-time version of MicroEDS, please follow the process below.

1. Purchase a commercial license from our website
2. Once the purchase has been verified by the credit card system, a six-character code will be sent to the user
3. Log into the MicroEDS system on the device where the commercial license should be located (see Figure 32)

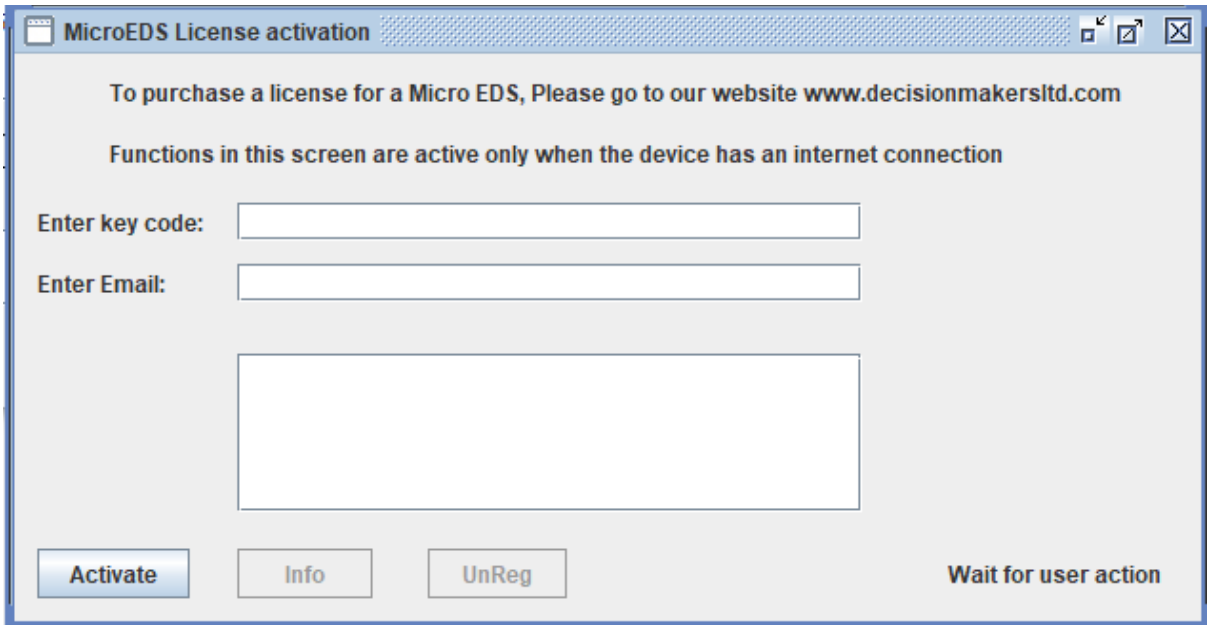


Figure 32: License activation screen

*

4. Enter the user's email and the six-character code
5. Click the Activate button

A message will be sent to our server if the MicroEDS device is online (connected to the internet).

If the MicroEDS device is not online, an activation file will be generated in the License subdirectory.

When the activation file reaches our server (online or offline), our server will send a message to the registration email with a link to a commercial version.