**TECHNICAL MANUAL**

# CAIRSENS

# MICROSENSOR

**- NOVEMBER 2020 -**



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**NOTE :** This technical manual applies only to Version-3 of the CAIRSENS released on May 2020, from serial number: 7073

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# CAIRSENS

# 1 GENERAL – CHARACTERISTICS

The set is composed of a storage box (1), a CAIRSENS for the appropriate pollutant measurement (2), a set of 2 dust filters and humidity buffers if applicable (3), and a standard mini-USB B to USB A cable (black, 50 cm) (4). This cable allows the 5 VDC power supply through the mini-USB port on the CAIRSENS rear panel and is used to download the data to USB via the CAIRSOFT software.


(1) Storage box, (2) CAIRSENS, (3) presence (or not) of two spare filters depending on CAIRSENS type (see Note below), (4) standard mini-USB B to USB A cable

**Figure 1-1 – CAIRSENS presentation**

**NOTE :** – A set of two white filters as spare is supplied with the $H_2S/CH_4S$, CO, $O_3/NO_2$, $SO_2$ and $NH_3$ CAIRSENS.

– The $NO_2$ CAIRSENS includes only one pre-assembled, blue-colored filter, which is different from the $H_2S/CH_4S$, CO, $O_3/NO_2$, $SO_2$ and $NH_3$ filters. This filter lifetime is one year. It is recommended not to handle nor replace this filter. However, if exceptionally, this filter needs to be changed, the user **must not** use his hands but pliers and gloves to handle it.

– The nmVOC CAIRSENS does not include filter.

The CAIRSENS supports three communication protocols: UART, USB and Modbus.

**WARNING : By default, the CAIRSENS operates under USB protocol on rear side (mini USB B port) and UART protocol on screen side (micro USB B port)**

The USB-mode CAIRSENS operates with a specific software for download, configuration, visualization and export data: the CAIRSOFT (V4.5 and more). This software is available free of charge in the « downloads » tab of our website www.cairpol.com.

CAIRSOFT operation is detailed in chapter 3 of this technical manual.

The CAIRSENS which operates under UART-protocol delivers an UART TTL 3V output signal. It is necessary to send the query frames to the CAIRSENS in order to obtain the desired data (see Appendix document). This communication mode allows developing numerous applications based on the CAIRSENS measurements.

**DO NOT directly link the CAIRSENS UART to an USB port of a PC. Use an UART to USB (FTDI 3v3) converter if necessary (converter not supplied).**

## 1.1 GENERAL

### 1.1.1 PRESENTATION

The CAIRSENS is a sensor which measures in continuous and in real time various gaseous pollutants present in the ambient air in a wide concentration range (from about tens of ppb to several ppm).

It performs indicative measurements of ambient air pollution: the allowed measurement uncertainty (+/- 25 to 30%) agrees with the data quality objectives defined by the European Directive 2008/50/EC for ambient air quality and cleaner air for Europe.

The CAIRSENS is manufactured and calibrated by ENVEA in its metrological qualification laboratory, with a validity period of one year. It is compact and consumes very few energy. It provides concentrations every minute, they are calculated from the running average of the measurements performed every second. Each CAIRSENS is delivered with its calibration certificate.

There are different CAIRSENS, each one is dedicated to the measurement of one the following pollutant(s):

- Nitrogen dioxide – $NO_2$
- Ammonia – $NH_3$
- Sulfur dioxide – $SO_2$
- Carbon monoxide – CO
- Hydrogen sulfide & methyl mercaptans - $H_2S/CH_4S$
- Ozone & Nitrogen Dioxide – $O_3/NO_2$
- Non-methane volatile organic compounds - nmVOCs

Each CAIRSENS is only intended for the measurement of one of these pollutants, and is calibrated in laboratory for this pollutant.

The CAIRSENS can be used autonomously with direct PC-retrieval of stored data. They can be integrated by six units (maximum) into the CAIRNET mini-stations to monitor several pollutants, or be custom-integrated into an air quality supervision network.

The most usual applications of the CAIRSENS are the following:

- Indoor and outdoor air quality monitoring: smart cities, roadsides and tunnels, schools, airports, ship terminals...
- Odour monitoring: WWTPs (wastewater treatment plants), recycling site, pulp and paper manufacturing, petrochemical refineries.
- Leak detection and furtive emission monitoring: quarries, storage installations, mines, manufacturing plants.
- Data providing for modelling atmospheric dispersion.
- Health and safety: mines, industrial sites, building.
- Emission forecasts at the industrial site boundaries.

### 1.1.2 DESCRIPTION

#### 1.1.2.1 Front panel

See Figure 1-2.

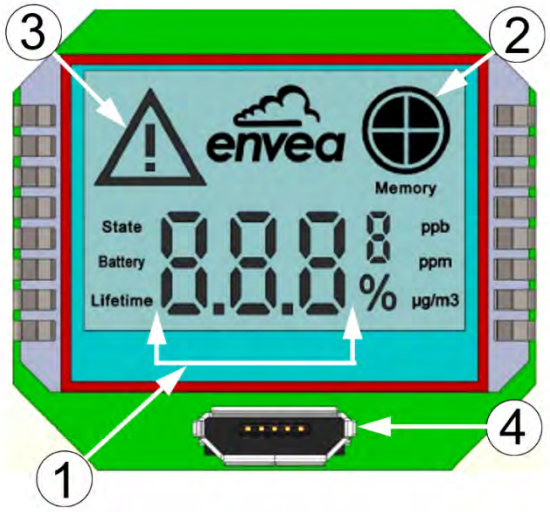
The front panel, protected by a polycarbonate plate, is fitted with:

– The LCD screen which displays :

- The measured concentration (1), represented by 3 digits, 1 exponent and 1 unit (see Chapter 2.).
- The status of the memory capacity used (2), by 25% fractions: when the whole memory is used, the circle quarters are black-filled.
- The possible CAIRSENS operation faults (3).

– The micro-USB B port (4), protected by a removable cap, which allows :

- The 5VDC CAIRSENS power supply,
- The UART CAIRPOL and UART MODBUS (slave mode) communication.




(1) measured concentration, (2) memory used, (3) operation errors, (4) micro USB B port

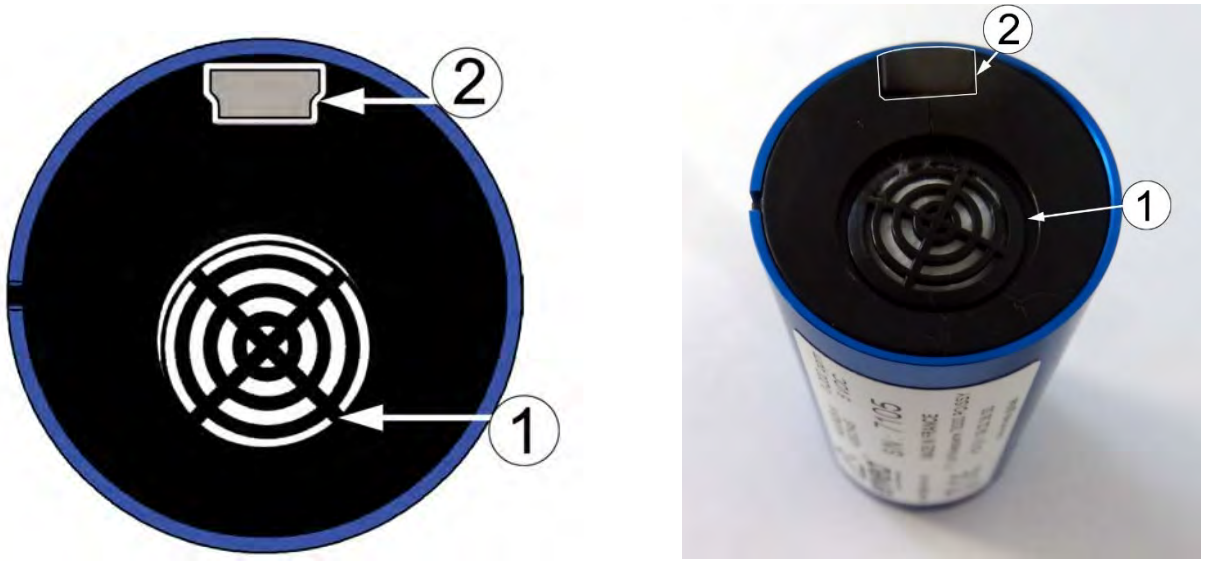
**Figure 1-2 – CAIRSENS front panel**

#### 1.1.2.2 Rear panel

See Figure 1-3.

The CAIRSENS rear panel includes the following elements:

- The sample inlet (1) fitted with a filter-holder which includes or not (depending on CAIRSENS model) a filter to protect the sensor from dust and moisture.
- The mini-USB port (2) driving the USB and UART communication, and enabling the 5VDC CAIRSENS power supply. This port is protected by a removable cap.




(1) Sample inlet, (2) mini-USB port with its removable cap

**Figure 1-3 – CAIRSENS rear panel**

### 1.1.2.3 CAIRSENS body

The CAIRSENS body includes the necessary measurement elements. It is protected by an external blue aluminum tube which keeps the elements in place and ensures the drawn-in air exhaust.

This CAIRSENS does not include internal Lithium battery, but only a button cell maintains the timestamp.

The fluid circuit is very simple: the air to be analyzed is drawn-in through the sample inlet by a built-in micro fan, then it is exhausted through the hole drilled on the external blue tube.

**WARNING: DO NOT obstruct the sample gas inlet (1) of Figure 1-3, nor its exhaust through the hole drilled on the external blue tube.**

The measurement cell is specific to the gas to be measured: each CAIRSENS measures the only gas(es) corresponding its built-in cell.

For the inorganic compound measurements, cells use an electrochemical measurement principle (amperometry). For the nmVOC compounds, the measurement principle is based on the UV-radiation photo ionization.

The following information are indicated on the CAIRSENS body: the gas(es) measured (1), the measurement range (2), the supply voltage for connection (3), the CAIRSENS reference (4) and its serial number (5).


(1) Gas(es) measured, (2) measurement range, (3) supply voltage,
(4) CAIRSENS reference, (5) serial number

**Figure 1-4 – CAIRSENS label**

The CAIRSENS and its accessories should not be eliminated in a traditional dustbin. They must be supported by a specialized recovery and recycling structure.

### 1.1.3 OPERATING MODES

#### 1.1.3.1 Standard

- Via the USB communication and internal memory use: stand-alone, with direct data download to a PC after measurement.
- Via the UART communication use: integrated into a CAIRNET mini-station in order to create an air quality monitoring network
- Via the UART or MODBUS communication use: integrated in a customized solution with data centralization on a DAS for air quality supervision and monitoring associated with other types of measurements (weather, noise, ...).

#### 1.1.3.2 Option

The CAIRSENS can be embedded in the following optional products:

- CAIRNET 3.0 :

  Standalone measurement station thanks to its internal battery rechargeable with photovoltaic panels or powered continuously by an 8 – 30 V voltage source. A 3G/4G cellular wireless communication module ensures the data transmission to the CAIRCLOUD (measurement management platform, remotely accessible from a secure web interface).

**NOTE :** The CAIRSENS is compatible with the former CAIRNET 2.0 products, the analog converter, the analog CAIRTUB, by switching the mini USB B port on the rear panel to the UART communication protocol, and the CAIRTUB USB.

### 1.1.4 ASSOCIATED EQUIPMENT

The CAIRSENS can be associated to the following equipment (not supplied):

- Analog/ digital converter
- Data Acquisition and Handling System: DAHS e-SAM.

**Technical characteristics of CAIRSENS sensors**

| Target gases | $NO_2$ | $O_3$ / $NO_2$ | $SO_2$ | CO | $H_2S$ / $CH_4S$ | | | $NH_3$ | | | VOCnm | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measurement range (ppm) | 0 - 0.25 | 0 - 0.25 | 0 - 1 | 0 - 20 | 0 - 1 | 0 - 20 | 0 - 200 | 0 - 25 | | | 0 - 2 | 0 - 16 |
| Detection limit (ppm) (1) | 0.02 | 0.02 | 0.05 | 0.05 | 0.01 | 0.03 | 0.20 | 0.50 | | | 0.20 | 0.50 |
| Resolution (ppm) | | 0.001 | | | | | | | | | | |
| Linearity | | < ± 10 % | | | | | | | | | | |
| Measurement uncertainty | ± 25 % (2) | ± 30 % (2) | ± 25 % (2) | ± 25 % (2) | ± 30 % | ± 30 % | ± 30 % | ± 30 % | | | ± 30 % (2) | ± 30 % (2) |
| Response time (1) | < 90 s | < 90 s | 90 s | < 90 s | < 90 s | < 90 s | < 90 s | 90 s | | | 60 s | 60 s |
| Calibration & carrier gases | $NO_2$ + humid air | $O_3$ + humid air | $SO_2$ + humid air | CO + humid air | $H_2S$ + humid air | | | $NH_3$ + humid air | | | Isobutylene ($C_4H_8$) + Synthetic air | |
| Sensitivity reference compound | $NO_2$ + humid air | $O_3$ + humid air | $SO_2$ + humid air | CO + humid air | $H_2S$ + humid air | | | $NH_3$ + humid air | | | Isobutylene ($C_4H_8$) + Synthetic air | |
| Quantification limit (QL) (ppm) (1) | 0.04 | 0.04 | 0.10 | 0.10 | 0.02 | 0.06 | 0.40 | 1.00 | | | 0.40 | 1.00 |
| Cross-sensitivity | $Cl_2$~ 80% | $Cl_2$~ 80% | $NO_2$ & $O_3$ ~ -125%<br>$H_2S$ ~ 5%<br>CO & $H_2$ <1 % | $H_2$ < 60 % | Other VRSC (4) ($SO_2$. OCS. $C_2H_6S$, $C_2H_6S_2$) < 100%<br>Oxidant species negative interference ($O_3$, $NO_2$) ~ 30% | | | Interferent<br>$SO_2$<br>$H_2S$<br>NO<br>$NO_2$<br>$Cl_2$ | Concentration<br>20 ppm<br>20 ppm<br>20 ppm<br>20 ppm<br>20 ppm | Reading<br>-7 ppm<br>7 ppm<br>-1 ppm<br>-20 ppm<br>-55 ppm | Available list on request (6) | |
| $O_3$ exposure limit | 7.5 ppm/day(3) | N/A | | | | | | | | | | |
| Sensor type | Electrochemical | | | | | | | | | | PID(5) lamp ionization potential = 10.6 eV (6) | |
| Operation temperature (°C) | -20 to +40 | | -20 to +50 | | -20 to +40 | | | | | | -20 to +50 | |
| Operation relative humidity (RH %) | 10 to 90 (without condensation) | | | | | | | | | | | |
| Operation pressure (mbar) | 1013 ± 200 | | | | | | | | | | | |

(1) Based on metrological qualification in laboratory (at 20 °C ± 2°C, 50 % RH ± 10 %, 1013 mbar ± 5 %)
(2) Compliant with data quality objectives for ambient air quality assessment regulation driven by European Directive 2008/50/EC for indicative measurements
(3) Ozone filter performance decreases over this limit.
(4) VRSC= Volatile Reduced Sulphur Compounds
(5) PID= Photo-Ionization Detector
(6) PID sensors allow the detection of VOC compounds with a ionization potential lower than the energy generated by the UV lamp

System features:

| | |
|---|---|
| Lifetime | 1 year warranty |
| Nominal power supply | 5VDC / 50mA<br>USB port connection of a PC |
| Energy consumption | < 20 mA for 5VDC power supply |
| Gas sampling method | Air sampling with a controlled micro-fan |
| Input/ Output ports | – Mini USB B (fan panel)<br>– Micro USB B (screen panel) |
| Communication protocols | – USB<br>– UART CAIRPOL<br>– UART Modbus RTU |
| LCD display | – Measured concentration and units<br>– Memory status<br>– Potential error (lifetime end, fan error, timestamp loss) |
| Management and data processing | – Internal microprocessor for data acquisition and processing<br>– Integrated Real Time Clock |
| Data memory storage | – 20 days of 1-min data<br>– 303 days of 15-min data<br>– 1212 days of 60-min data |
| Data download | – CAIRSOFT software: graphs and table .xls format, data export to CAIRCLOUD (option)<br>– DAHS (as ENVEA eSAM Data Acquisition and Handling System) |

Compliance with environmental regulation:

| | |
|---|---|
| Electric safety | NF EN 61010-1 : 2010 |
| Electromagnetic compatibility | NF EN 61326-1 : 2013 |
| Protection index | IP 42 (according to IEC 60529) |
| Data quality objectives for ambient air quality assessment (indicative measurements) | 2008/50/CE |

### 1.2.2 STORAGE CHARACTERISTICS

| | |
|---|---|
| Temperature (°C) | +5 à +20 |
| Relative Humidity (% RH) | > 15 (without condensation) |
| Maximum storage time without use | – 3 months for all the gas CAIRSENS,<br>– 6 months for the nmVOC CAIRSENS. |

### 1.2.3 INSTALLATION CHARACTERISTICS

#### 1.2.3.1 Links between units

The CAIRSENS uses the external links and supplies shown in the figures below:

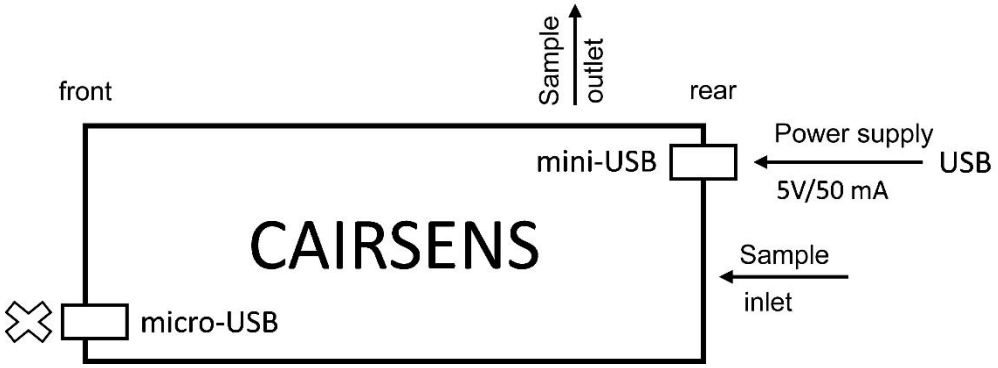



**Figure 1-5 – CAIRSENS links between units for stand-alone USB operation**

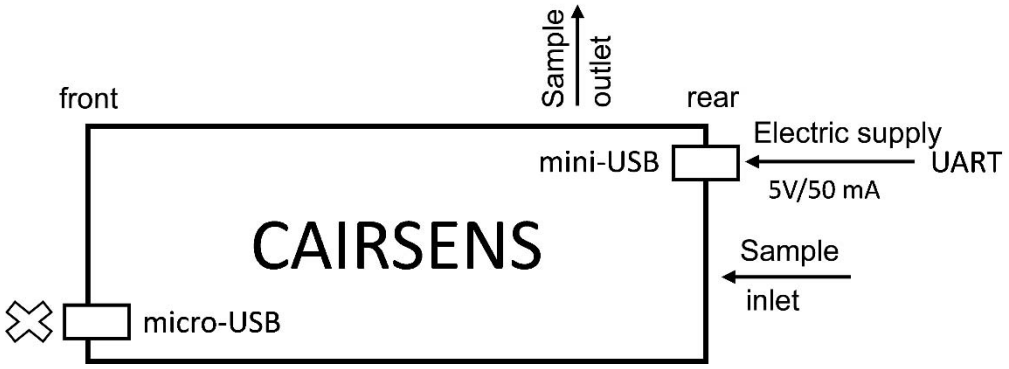



**Figure 1-6 – CAIRSENS UART links between units for system integration via rear panel (CAIRNET 2.0 type)**

**For CAIRSENS integration via mini USB B connector under UART communication, first switch from USB mode to UART via the application (see section 3.1.5).**

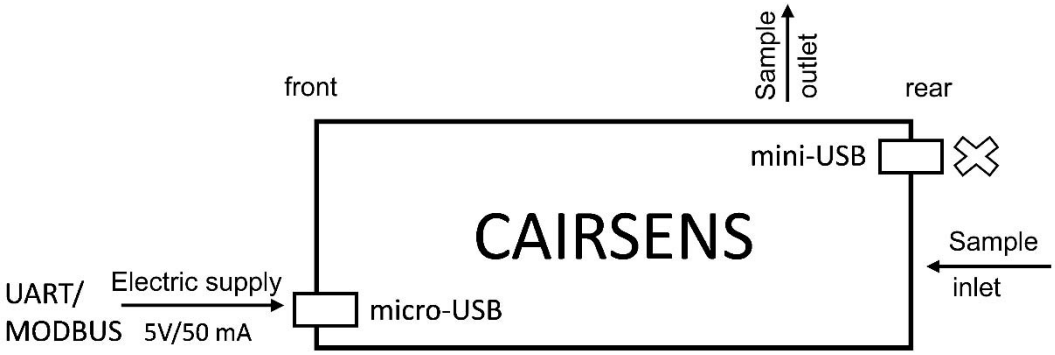



**Figure 1- 7 – CAIRSENS UART or MODBUS links between units for system integration via front panel (CAIRNET 3.0 type)**

### 1.2.3.2 Dimensions and weight

The CAIRSENS is in the form of a cylinder:

Length : 62.7 mm

Diameter : 32.2 mm

Weight : 47 g

### 1.2.3.3 Handling and storage

The CAIRSENS must be handled with precautions.

It should be stored in the box provided for this purpose.

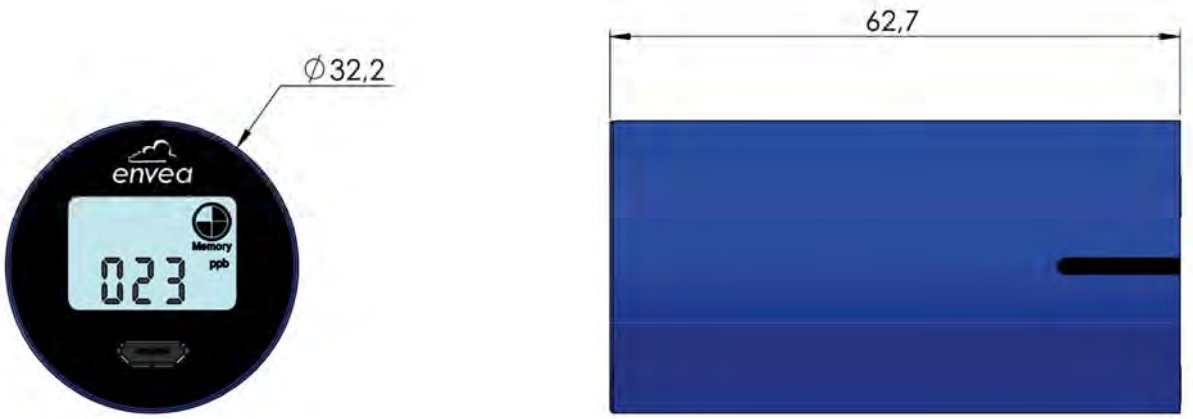



**Figure 1-8 – CAIRSENS dimensions (in mm)**

# 2 MEASURE

## 2.1 CONCENTRATION READING ON DISPLAY

See Figure 2-1.

The numerical value of the measured concentration is given by the formula:

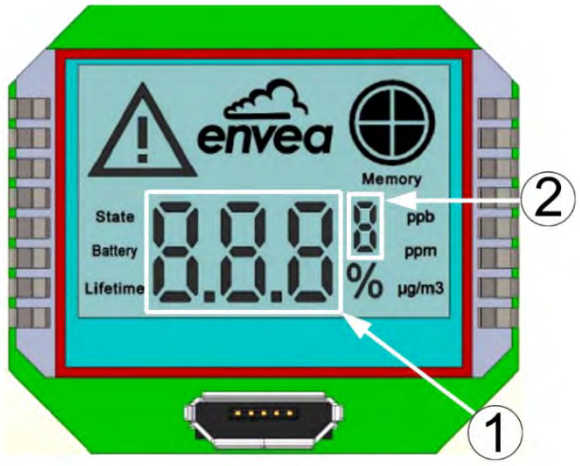
$$XXX \times 10^{y}$$

Where:

- XXX is the measurement value displayed on the three digits of the screen (1)
- ✖ is the multiplication operator
- $10^{y}$ is the multiplying coefficient to be applied to XXX. The “y” value is displayed in (2) on the screen.

As example, the concentration value for y = 0, y = 1 and y = 2 is given in the below table:

| y value | $10^{y}$ value | Concentration value reading |
|---|---|---|
| y = 0 | $10^{0} = 1$ | XXX ✖ 1 = XXX |
| y = 1 | $10^{1} = 10$ | XXX ✖ 10 = XXX0 |
| y = 2 | $10^{2} = 100$ | XXX ✖ 100 = XXX00 |





Concentration reading : 398 ppb


Concentration reading: 2220 ppb


Concentration reading: 12200 ppb

(1) Measured value displayed on three XXX digits, (2) « y » value in the formula: XXX ✖ $10^{y}$

**Figure 2-1 – Concentration display**

## 2.2 MEASUREMENT PERFORMED BY CAIRSENS

The measurements displayed on the screen are carried out as follows:

- Running average of CAIRSENS measurements during 60 seconds.
- Refreshment of this value each ten seconds on screen.

The frequency of measurements stored in the CAIRSENS memory can be set in 1 min (default), 15 min, or 1 hour using the CAIRSOFT software. Pay attention: this parameter has a direct influence on the data volume to be stored and thus on the CAIRSENS memory capacity.

## 2.3 FILTER FUNCTION

The filter is essential for correct CAIRSENS operation, it enables conditioning of the sample to be measured. Placed on the sample inlet, it ensures the pollutant passage and protects against dust and moisture.

**WARNING: the filter must be handled with care: DO NOT move the filter out of its filter-holder and DO NOT hold it with fingers (see Maintenance operation).**

# 3 OPERATION

## 3.1 COMMISSIONING

### 3.1.1 INITIAL START-UP

CAIRSENS starts-up as soon as it is powered-up: CAIRSENS starts measurements as soon as it is running. The measurements are immediately displayed on the screen and stored automatically. The measurement backup is permanently performed in the CAIRSENS internal memory. It is recommended to use the measurements only after 24 hours which is the time necessary for the sensor to be conditioned to its environment.

By default, the CAIRSENS is in continuous measurement mode, and the measurement period (or time step) is 1 minute. It can be modified to 15 min or 1 h with the CAIRSOFT software.

When the CAIRSENS memory is full, this one continues to operate normally, but it records the new measurements overwriting the oldest ones.

**WARNING: The user must retrieve data regularly before reaching the maximum storage capacity of the CAIRSENS in order to avoid losing measurements.**

When starting-up, all the pictograms are displayed by default (Figure 3-1):


**Figure 3-1 – Display screen on CAIRSENS start-up**

**CAIRSENS calibration and measurement are guaranteed to be valid for 12 months after delivery.**

CAIRSENS life time is 12 months (8760 h use). When this is over, the screen display is: cAL (Figure 3-2). It is then necessary to replace the CAIRSENS by a new one.


**Figure 3-2 – Display screen at the life time end**

**WARNING: By default, the CAIRSENS operates under USB protocol on rear panel (mini USB B port) and UART protocol on screen panel (micro USB B port)**

### 3.1.2 HOUR, DATE AND TIMESTAMP OF MEASURED DATA

The CAIRSENS internal clock is preset factory, a button cell ensures the clock backup. Before any use or measurement campaign, its setting must be checked.

If the CAIRSENS loses its clock setting:

- The CAIRSENS display indicates the « dAt » alert (Figure 3-3).
- Set the time and date using the CAIRSOFT software. As soon as the setting is done, the measurement timestamp will resume from the new date and time set.

If setting is not performed, the measurements will be time-stamped from 01/01/2030.


**Figure 3-3 – Display of clock setting alert**

### 3.1.3 COMMISSIONING AFTER A LONG STORAGE TIME

The maximum storage time without CAIRSENS use is 3 months (6 months for nmVOCs).

A prolonged storage (more than 4 weeks) has a direct effect on the CAIRSENS performances during the first few days of use after its re-commissioning. **It is strictly recommended to keep the CAIRSENS constantly powered-on by applying the storage conditions.**

The CAIRSENS requires reconditioning to recover its accuracy. It is therefore strongly recommended to recondition the electrochemical CAIRSENS cell, choosing one of the two following methods:

#### 3.1.3.1 Fast reconditioning

This reconditioning is performed with a span gas cylinder containing the gas mixture to be tested with synthetic air (20.9% oxygen):

- (a) Use an airtight* volume (for example: a nalophan bag).
- (b) Place the CAIRSENS inside this volume * during 10 minutes.
- (c) During 10 additional minutes, inject a concentration equal to:
  - The maximum range, for a CAIRSENS with a measurement range equal or lower than 0/1000 ppb.
  - Equivalent to 1/20$^{th}$ of the maximum range, for a CAIRSENS with a measurement range greater than 1000 ppb.
- (d) Empty the content volume (open it or remove the gas still present) up to a gas concentration close to "zero" ppb.
- (e) Repeat once from step (b).

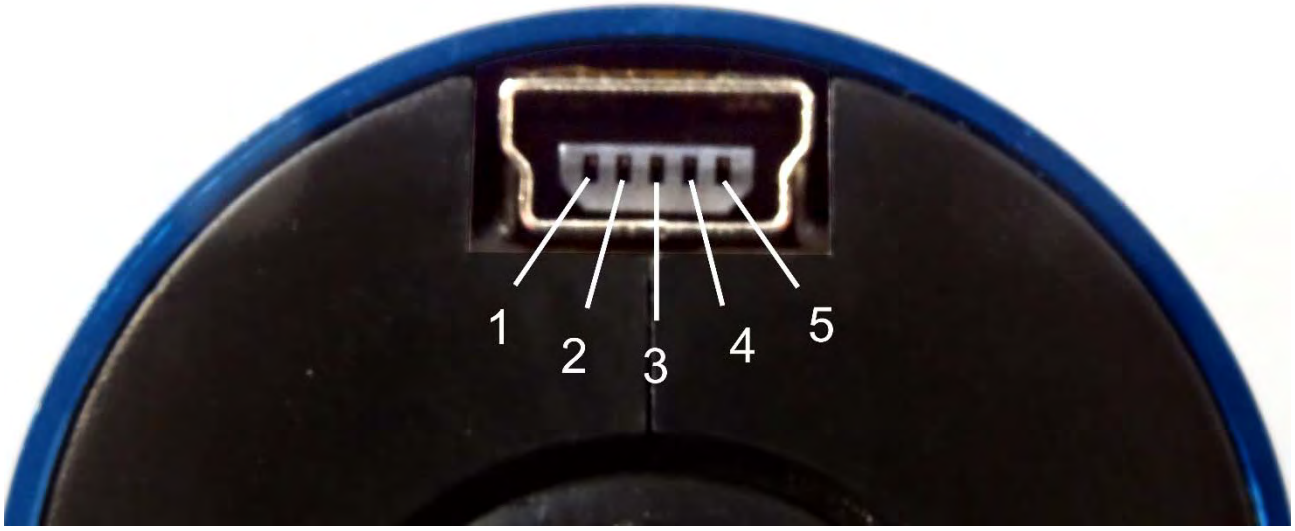
** WARNING: a minimum of 10 % relative humidity must be present in the volume.*

#### 3.1.3.2 On-site reconditioning with ambient air

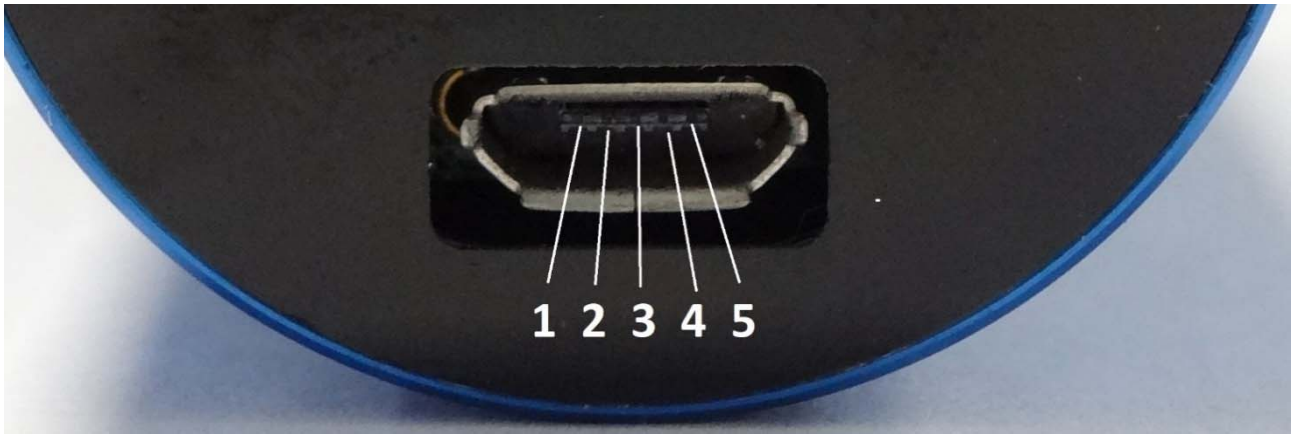
- The electrochemical CAIRSENS cell will reconditioned in the ambient air in the presence of the pollutant to be measured. This method requires much more time than the previous one.
- It is recommended to use the measurements after only a period of at least 48 hours (time required for an optimal reconditioning).

### 3.1.4 CAIRSENS WIRING FOR SYSTEM INTEGRATION

Wiring required for CAIRSENS integration into a system are given below:




**Mini USB connector, filter panel**




**Micro USG connector, screen panel**

The pin and cable correspondence for CAIRSENS connection via the mini or micro USB connector to standard USB A connector is shown in the table :

| Pin | | Description | Wire color |
|---|---|---|---|
| USB A | Mini/Micro USB B | | |
| 1 | 1 | VDC +5V | Red |
| 2 | 2 | Data - | White |
| 3 | 3 | Data + | Green |
| | 4 | Not used | Brown |
| 4 | 5 | GND Ground | Black |

**Figure 3-4 – Wiring instructions for USB A connection to mini or micro USB B**

To connect a CAIRSENS operating under UART protocol to a computer, it is necessary to connect a FTDI TTL 3V3 converter (not supplied) to the mini or micro USB port (depending on the UART configuration type) of the CAIRSENS. The color code for this wiring is shown in the table below:

| FTDI cable | | | Mini/Micro USB | | |
|---|---|---|---|---|---|
| Pin | Description | Cable color | Pin | Description | Cable color |
| 1 | GND | Black | 5 | GND | Black |
| 3 | VCC | Red | 1 | VCC | Red |
| 4 | TXD | Orange | 3 | D + | Green |
| 5 | RXD | Green | 2 | D - | White |

### 3.1.5 COMMUNICATION PROTOCOLS

The CAIRSENS supports three communication protocols, UART, USB and Modbus:

- Front panel micro-USB B: UART Cairpol (by default) or UART Modbus.
- Rear panel mini-USB B: USB (by default) or UART Cairpol.

Thus, 4 configurations are possible (see picture).

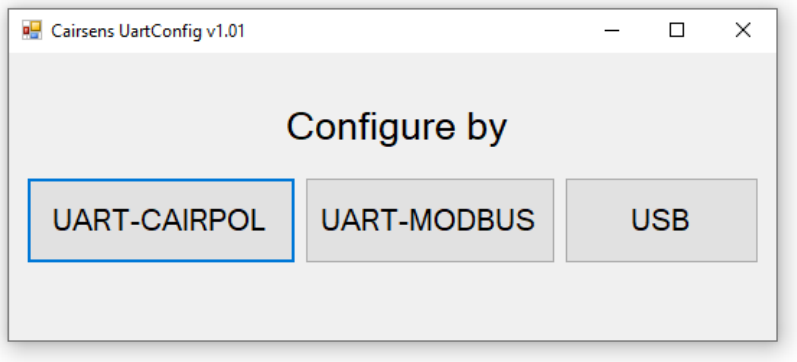
**WARNING: By default, the CAIRSENS operates in USB protocol on the rear panel (mini USB B port) and in UART protocol on the screen panel (micro USB B protocol).**

To change the communication protocol on the mini-USB port and micro-USB port of the CAIRSENS, connect it to a PC with the USB cable provided with the CAIRSENS, or with an UART to USB (FTDI 3v3, not provided) converter if it operates under UART protocol.

1. Connect the CAIRSENS to the PC with the suitable cable depending on its operating mode and the port used.

2. Execute Cairsens_UartConfig.exe (v1.01 or more) freely downloadable from the web site « www.cairpol.com », at the same place than CAIRSOFT: « Downloads/ Technical resource » tab, then « Software ».

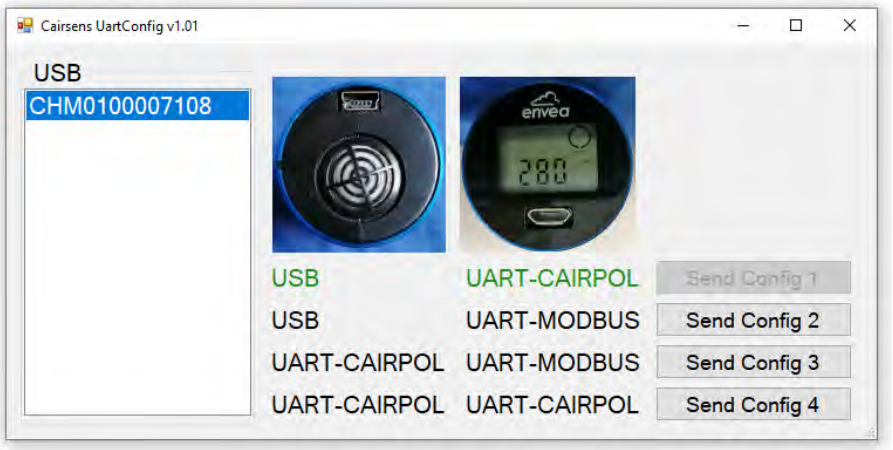
3. Select the current CAIRSENS operating mode.




4. Select the recognized CAIRSENS (identifier ending with the 4 digits of its serial number). Its current configuration is displayed in green, Config 1 by default, USB/UART-CAIRPOL.

The left column, below the rear panel picture of the CAIRSENS, indicates the mini-USB B port (USB or UART-CAIRPOL) configuration. The right column, below the screen picture, indicates the micro-USB B port (UART-CAIRPOL or UART-MODBUS) configuration.

5. In order to change the configuration, double-click on the desired configuration (ex.Send Config 2). When the operation is finished, the new configuration is displayed in green. If the communication modification impacts the currently-used connector, it is necessary to re-start the application to view the modification. Close the software, and disconnect the CAIRSENS.



## 3.2 CAIRSOFT OPERATING SOFTWARE

The configuration of some CAIRSENS parameters (Clock setting, naming, etc...) is possible using the CAIRSOFT software (V4.5 and more). The CAIRSOFT software allows the visualization, processing and export of the CAIRSENS data.

CAIRSOFT can be free-downloaded from the web site « www.cairpol.com », then « Downloads/ Technical resource » tab and « Software ».

### 3.2.1 REQUIREMENTS

The requirements are as follows:

- Operating systems supported :

  Windows Vista SP2

  Windows 7 SP1

  Windows 8

  Windows 8.1

  Windows 10

  Windows Server 2008 SP2

  Windows Server 2008 R2 SP1

  Windows Server 2012

  Windows Server 2012 R2

- Minimum hardware requirements:

  Minimum 1 GHz processor

  512 Mo random access memory (RAM)

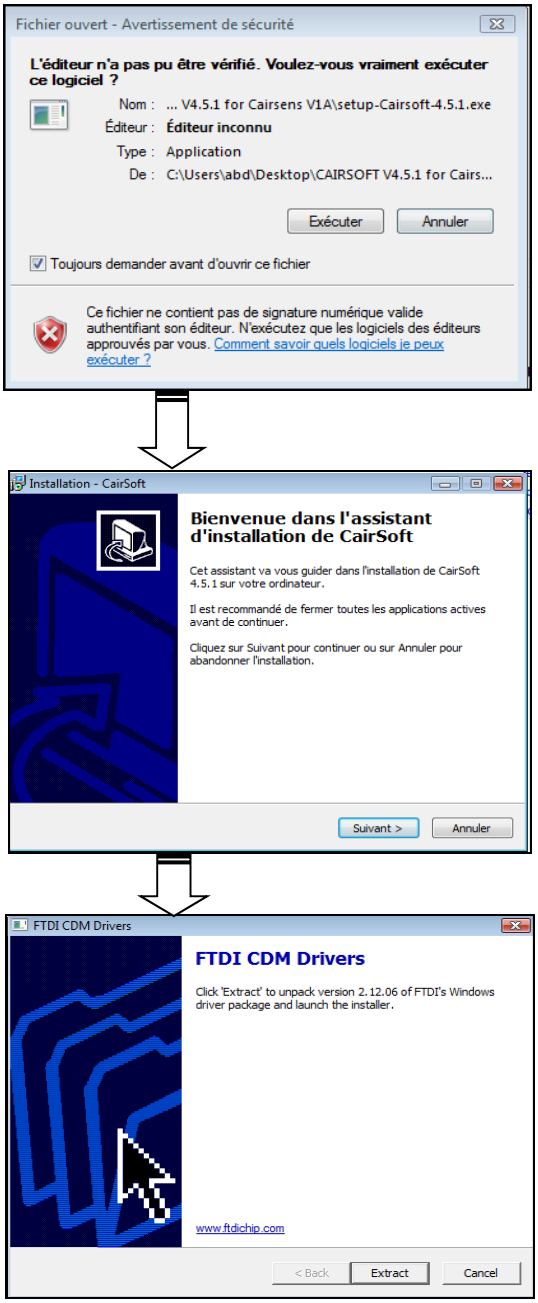
- Microsoft .Net Framework 4.6 and higher

### 3.2.2 WEB DOWNLOAD

The download procedure to follow is below:

- From a browser, go to the www.cairpol.com website, and click on the "Downloads" menu, then on the "Technical Resource" menu and the "Software" item.
- Start « **CairsoftV4.x.x** » download (CAIRSOFT V4.5 and more).
- Record the setup « **setup-Cairsoft-4.x.x.exe** » (CAIRSOFT V4.5 and more).

### 3.2.3 CAIRSOFT INSTALLATION




1 – Launch the setup « setup-Cairsoft-4.x.x.exe » (CAIRSOFT V4.5 version and more).

2 – Follow the instructions of the installer.

3 – The installer checks for the required framework version (see § Requirements). If this version is not available on your PC, it will be automatically installed (internet access required).

Without internet connection, the framework 4.6 (and more) can be installed manually. Resume from step a) when the installation is finished.

4 – Validate the « *FTDI CDM* » driver installation and follow installer instructions.

5 – Complete the installation.

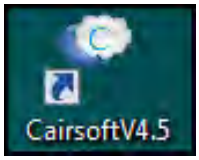
6 – The CAIRSOFT is ready to be used.

### 3.2.4 CAIRSENS CONNECTION TO PC

The CAIRSENS has to be connected to the PC with the specific « USB A » to mini « USB B » cable provided with the CAIRSENS.

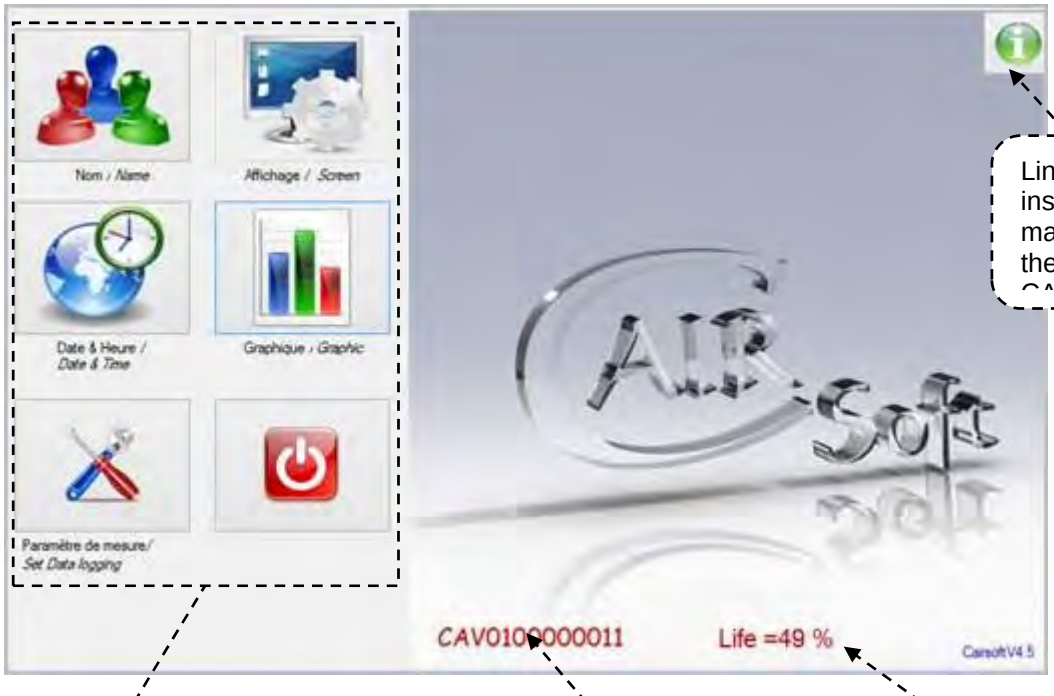
**DO NOT use any other USB cable than the one provided with the CAIRSENS, otherwise this could damage the equipment.**

### 3.2.5 CAIRSOFT STARTING UP





- Connect the CAIRSENS to the PC with the USB cable.
- Launch the CAIRSOFT from the « *CairsoftV4.x* » shortcut *(Version CAIRSOFT V4.5 and more)* on the desk or from the « *Cairpol* » folder in Start menu.
- The download windows is displayed, the downloading of all the CAIRSENS data begins. **Do not disconnect the CAIRSENS from the PC.**
- When downloading is finished, the main window of CAIRSOFT is displayed and gives access to :
  - The main menu comprising five icons to customize the CAIRSENS and visualize the history of measurements, hygrometry and battery voltage level.
  - This CAIRSOFT instruction manual, accessible from the icon on the top right side of the main window.



### 3.2.6 CAIRSENS CONFIGURATION

#### 3.2.6.1 CAIRSENS name

The default name of the device is its serial number (example: « *CCB0100000891* »).


– Click on the icon « *Name* » to modify it.


– The «*Name*» secondary window is displayed: in the *« Name »* text field, enter the new CAIRSENS name.

– Click on the green button to validate the name change.

– To cancel and return to the main window, click on the red « Cancel » button.


– The new name is memorized in the CAIRSENS and appears in the main window of the CAIRSOFT.

– The CAIRSENS name can be modified as desired.

#### 3.2.6.2 CAIRSENS display mode


– Option disabled for CAIRSOFT V4.5.1 version and more.

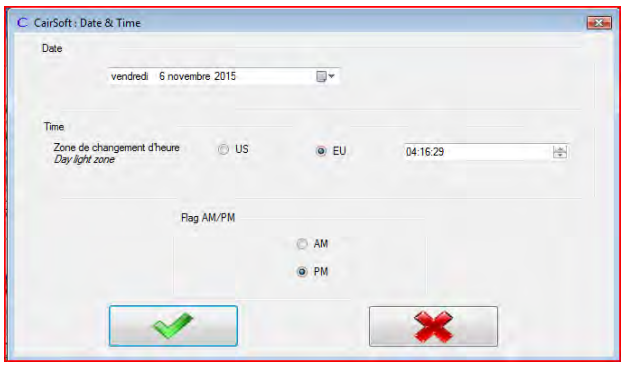
### 3.2.6.3 CAIRSENS date and time

If the timestamp is lost, it automatically resets to the date "2000.01.01" and the time to "00:00".

In this case, it is recommended to proceed to the CAIRSENS time setting, in order to get a valid data timestamp.

This feature uses the “Date” and “Time” functions of the PC to which the CAIRSENS is connected


– Click on the « Date & Time » icon to start date and time settings of the CAIRSENS.



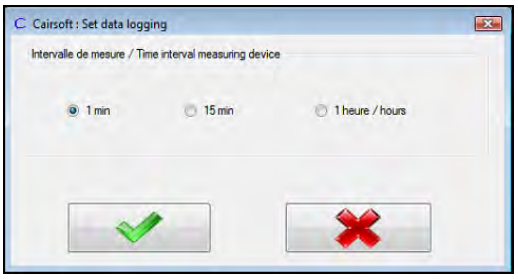

– Select the desired geographic area (EU or US).
– Select the desired ‘’time’’ format (AM or PM).
– Click on the green button to validate.
– Click on the red button to abort and return to the main window.

### 3.2.6.4 Sampling / Measurement interval

This feature enables to change the measurement time. The CAIRSENS performs continuous measurements and can perform 1-minute, 15-minute or 1-hour averages, as desired.

The measurement interval selected affects directly the number of data backed-up in the CAIRSENS.

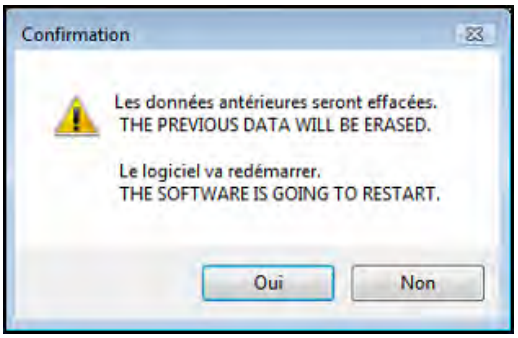

– Click on the *« Set data logging »* to change the time interval between 2 measurements.




– The « *Set data logging* » is displayed.

– Select the measurement time interval desired.

– Click on the green button to validate (or on the red button to abort).




– A « Confirmation » window is displayed: confirm your choice by clicking on « oui »“(it is always possible to abort by clicking on « non »).

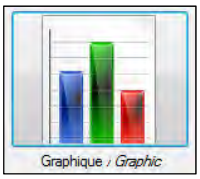
**IMPORTANT : if the confirmation is accepted, then the data previously backed-up will be deleted from the CAIRSENS memory.**

**The CAIRSOFT software will restart with the new CAIRSENS setting (do not disconnect the CAIRSENS from the PC).**

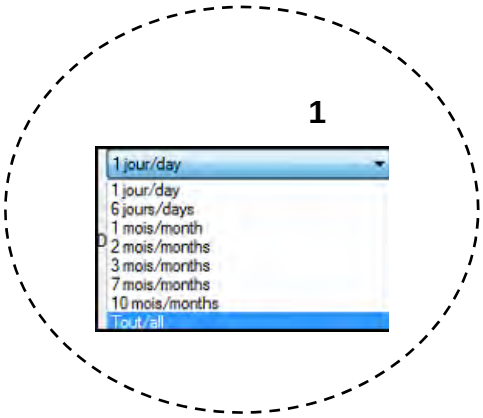
### 3.2.6.5 Visualization on the graph and export in .csv format

This feature enables to visualize and/or export (under .cvs format) the measurement performed by the CAIRSENS during one or several days.

By default, the visualization and export period is one day, and the concentration is stated in ppb. It is possible to visualize and export all the data and parameters available in memory.




In the main CAIRSOFT window, click on the "Graphic" logo.

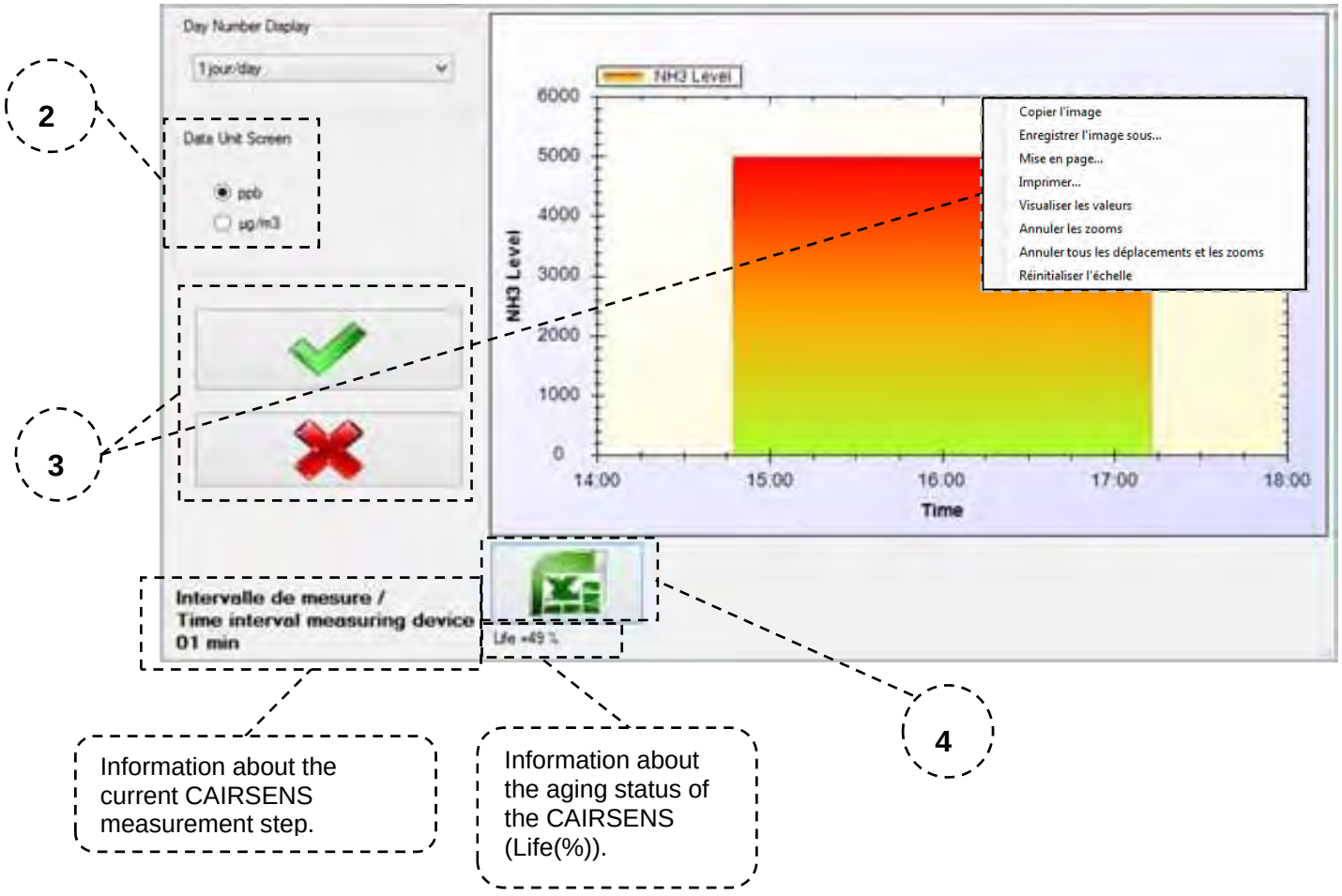



(1) Select the measurement period: 1 day or all the measured data (the other selections, 6 days, 1 - 2 - 3 - 7 and 10 months, are no longer active).

(2) Select the measurement (ppb or µg/m$^3$ ) of the graph and excel table.

(3) Click the green "**Validate**" button to refresh the graph. An interactive menu (modify, zoom; print,...) is available by right-clicking on the graph.

(4) To export under .XLSX format, click on the Excel logo (Microsoft copyright).



### 3.2.6.6 Visualization of measurement and other data on the .XLSX type table

The export under .xlsx format allows to retrieve the following parameters:

- The CAIRSENS reference (1).
- The time stamp (2) corresponding to the period selected in "Measurement parameter".
- The measurements with the units (3) selected in the « Graphic ».
- The battery voltage in mV (4) is translated as follow :
  - ≥ 4700 mV = Plugged onto external power.
  - 4200 <mV<3100 = On battery only / without external power.
  - 4200 mV = the battery is fully charged.
  - 3100 mV = the battery is empty and must be recharged.

Only valid for the prior-to-2020 former CAIRSENS versions running on batteries.

- The temperature measurement in °C. (5), if applicable,
- The relative humidity measurement HR in %. (6), if applicable,
- The CAIRSENS aging in % (7), it is translated as follow :
  - 100% = 0 month of operation.
  - 50% = 6 months of operation.
  - **00% = 12 months of operation**.

In this case, the corresponding **measurement boxes** in the table are red-colored and the CAIRSOFT graph frame changes from blue to red (see Figure 3-6).

| | A | B (1) | C (4) | D | E (7) | F |
|---|---|---|---|---|---|---|
| 1 | Equipment number | CHM0100000002 | V(%) | 0 | Life(%) | 100 |
| 2 | Time (2) | Eq. H2S (TRS) Level (ppb) | Bat.(mV) | Temp. hygro °C | Hygro. % (6) | |
| 3 | 08/11/2015 08:41:00 | 1 (3) | 4710 | 25 (5) | 35 | |
| 4 | 08/11/2015 08:42:00 | 1 | 4710 | 25 | 35 | |
| 5 | 08/11/2015 08:43:00 | 0 | 4711 | 25 | 35 | |
| 6 | 08/11/2015 08:44:00 | 1 | 4709 | 25 | 35 | |
| 7 | 08/11/2015 08:45:00 | 1 | 4710 | 25 | 35 | |
| 8 | 08/11/2015 08:46:00 | 1 | 4710 | 25 | 35 | |
| 9 | 08/11/2015 08:47:00 | 1 | 4711 | 25 | 35 | |
| 10 | 08/11/2015 08:48:00 | 1 | 4709 | 25 | 35 | |
| 11 | 08/11/2015 08:49:00 | 1 | 4711 | 25 | 35 | |
| 12 | 08/11/2015 08:50:00 | 1 | 4711 | 25 | 35 | |
| 13 | 08/11/2015 08:51:00 | 1 | 4708 | 25 | 35 | |
| 14 | 08/11/2015 08:52:00 | 1 | 4710 | 25 | 35 | |
| 15 | 08/11/2015 08:53:00 | 0 | 4710 | 25 | 35 | |
| 16 | 08/11/2015 08:54:00 | 1 | 4711 | 25 | 35 | |
| 17 | 08/11/2015 08:55:00 | 1 | 4711 | 25 | 35 | |
| 18 | 08/11/2015 08:56:00 | 1 | 4709 | 25 | 35 | |
| 19 | 08/11/2015 08:57:00 | 1 | 4711 | 25 | 35 | |
| 20 | 08/11/2015 08:58:00 | 1 | 4711 | 25 | 35 | |

data

**Figure 3-5 – Measurement visualization in .XLSX table**

Example of a CAIRSOFT graph whose electrochemical cell operated during more than 12 months (Life = 00%):

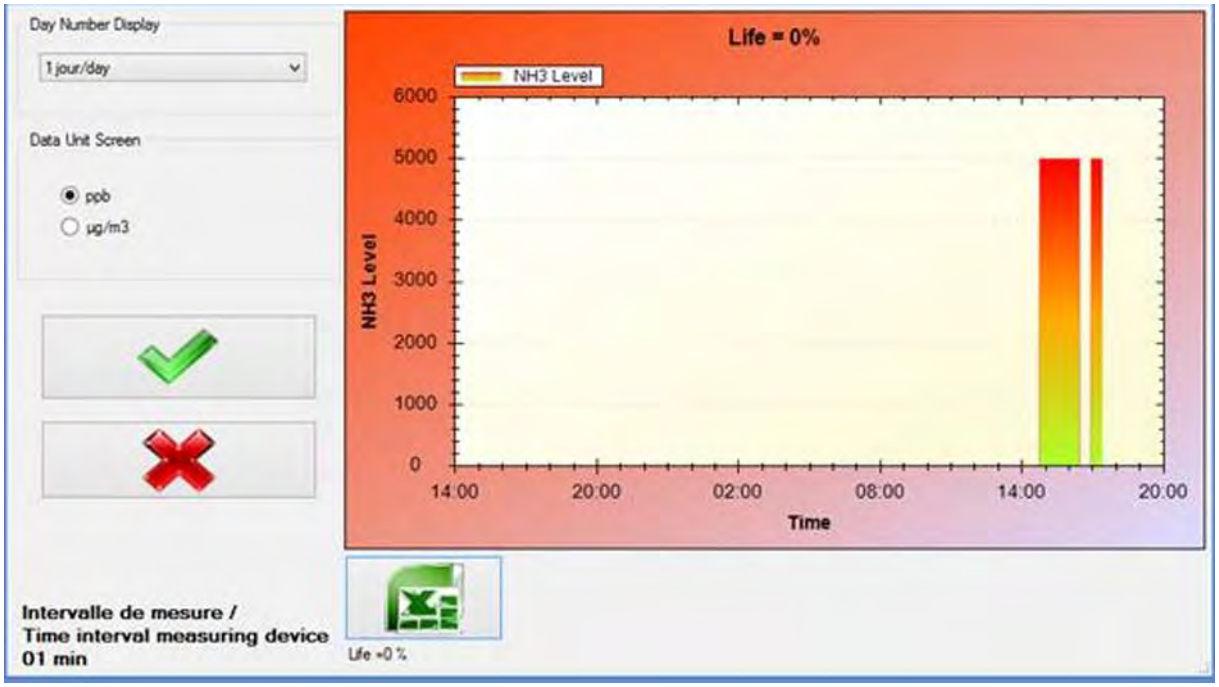



**Figure 3-6 – CAIRSOFT graph of an electrochemical cell after 12 months operation (Life = 00%)**

## 4 OPERATION FAULT DISPLAY

The detectable fault are:

| | |
|---|---|
|  | **CAL lifetime error**<br>**cAL**: The CAIRSENS reached its lifetime end of 1 year. After this period, the measurement and calibration of CAIRSENS are no longer guaranteed, the measurement accuracy is damaged. It is recommended to renew the CAIRSENS (contact ENVEA by email at info@cairpol.com). |
|  | **Date error**<br>**dAt**: the CAIRSENS date and time are not set or were lost (by default, return to 01/01/2000). It is advised to re-synchronize the date and time using the CAIRSOFT software (see 3.2.6.3). |
|  | **Fan error**<br>**FAn**: the fan ensuring dynamic air sampling is not operating correctly. Check that the fan is running normally and not obstructed. If the problem is persistent, contact ENVEA by e-mail at support@cairpol.com. |
|  | **Full memory error**<br>The CAIRSENS continues to operate normally, but records the new measurements by overwriting the oldest measurements.<br>The user must retrieve data regularly before reaching the maximum storage capacity of the CAIRSENS in order to avoid losing measurements. |

# 5 CAIRSENS MAINTENANCE

## 5.1 SAFETY INSTRUCTIONS

The safety instructions must be observed at any time by the user.

- Switch off the power supply when servicing the CAIRSENS.

  Do not connect the CAIRSENS to both the mini-USB port and the micro-USB port at the same time, otherwise irreversible damage may occur.

- Personnel must be properly trained to correct CAIRSENS operation before starting to operate it.

- Use only the provided accessories (USB cable, filter).

- Do not obstruct the filter, the fan, or the side hole for air exhausting.

- Do not hold the CAIRSENS in hands during the measurements.

- Do not use the CAIRSENS in a dusty, corrosive, explosive environment, and in the presence of other gases (combustion gases, solvent, chlorine, acid and basic vapors, etc.).

- Respect the conditions of use (see Technical characteristics).

Concerning safety, the manufacturer shall not be responsible for any adverse outcomes resulting from the followings:

- Use of the device by unqualified service personnel.

- Use of the device under conditions other than those specified in this document.

- Use of spare parts or accessories not manufactured by ENVEA. Failure to use recommended parts may reduce the safety features.

- Use of this equipment in a manner not approved by ENVEA is not recommended and may result in damage to personnel and equipment.

- The device modification by the user.

- No-maintenance of the device.

## 5.2 MAINTENANCE OPERATION

- To replace the white filter (recommended twice a year, or if the CAIRSENS filter, when present, is deemed unsuitable):
  - Disconnect the CAIRSENS from any power supply.
  - Remove the filter holder by its rim, avoiding contact with its white central part. Pay attention to the filter protection grid / fan.
  - Insert the new filter by its rim, avoiding contact with its white central part.
  - After this replacement, 12 hours are needed to stabilize the measurements.

Respect the following instructions:

- Do not store the CAIRSENS in a polluted environment, and respect the storage conditions (see § 1.2.2 Storage characteristics).
- If necessary, clean it only with a clean and dry cloth.
- Perform any maintenance operation free from dust and water splashes.

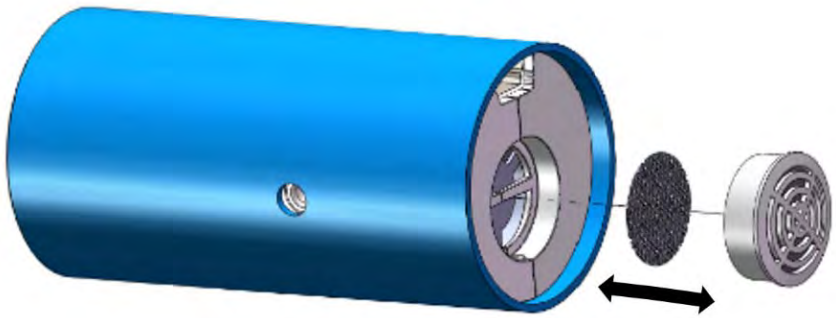


**Figure 5-1 – CAIRSENS filter replacement**

# 6 APPENDICES

6.1 MODBUS PROTOCOL

6.2 CAIRSENS UART PROTOCOL

6.3 DRAWING

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# Modbus RTU for CAIRSENS

Version 1.0.1

# Table of Contents

# 1 General

## 1.1 Overview

The official Modbus specification can be found at www.modbus.org/specs.php

| Version | Date | Comments |
|---|---|---|
| 1.0.0 | July 2019 | Initial manual |
| 1.0.1 | November 2020 | Fix address |

## 1.2 Available functions codes

| Code | Action |
|---|---|
| 03 | Read holding registers |
| 06 | Write single holding register |
| 16 | Write multiple holding registers |
| 23 | Read and write multiples holding registers |

# 2 MODBUS mapping

## 2.1 Information

| Address | Register | Access | Data | Description |
|---|---|---|---|---|
| 0 .. 9 | 1 .. 10 | R | String | ENVEA |
| 10 .. 19 | 11 .. 20 | R | String | Version( ex 1.52 ) |
| 20 .. 29 | 21 .. 30 | R | String | Serial |
| 30 .. 39 | 31 .. 40 | R | String | Gaz ( ex CO ) or Dust |

## 2.2 Date and time

| Address | Register | Access | Data | Description |
|---|---|---|---|---|
| 40 | 41 | R/W | uint16 | Year ( ex 2019 ) |
| 41 | 42 | R/W | uint16 | Month ( 1 to 12 ) |
| 42 | 43 | R/W | uint16 | Day ( 1 to 31 ) |
| 43 | 44 | R/W | uint16 | Hours ( 0 to 23 ) |
| 44 | 45 | R/W | uint16 | Minutes ( 0 to 59 ) |
| 45 | 46 | R/W | uint16 | Seconds ( 0 to 59 ) |

## 2.3 Cairsens

### 2.3.1 Internal parameters

| Address | Register | Access | Data | Description |
|---|---|---|---|---|
| 70 | 71 | R | uint16 | Fan Speed ( rpm) |
| 71 | 72 | R/W | uint16 | Fan configuration( % ) |
| 72 .. 73 | 73 .. 74 | R | float | Max Range ( ppb ) |
| 74 | 75 | R | uint1 | Life sensor aging state in % |

### 2.3.2 Measure

| Address | register | Access | Data | Description |
|---|---|---|---|---|
| 80 .. 81 | 81 .. 82 | R | float | Measure( ppb ) |
| 82 .. 83 | 83 .. 84 | R | float | Measure( µg/m3 ) |

### 2.3.3 Stored data (ppb)

| Address | Register | Access | Data | Description |
|---|---|---|---|---|
| 100 .. 101 | 101 .. 102 | R | float | Last memorized value T0 |
| 102 .. 103 | 103 .. 104 | R | float | memorized value T0- 1 minute |
| 104 .. 105 | 105 .. 106 | R | float | memorized value T0- 2 minutes |
| 106 .. 107 | 107 .. 108 | R | float | memorized value T0- 3 minutes |
| 108 .. 109 | 109 .. 100 | R | float | memorized value T0- 4 minutes |
| 110 .. 111 | 111 .. 112 | R | float | memorized value T0- 5 minute |
| 112 .. 113 | 113 .. 114 | R | float | memorized value T0- 6 minute |
| 114 .. 115 | 115 .. 116 | R | float | memorized value T0- 7 minute |
| 116 .. 117 | 117 .. 118 | R | float | memorized value T0- 8 minute |
| 118 .. 119 | 119 .. 120 | R | float | memorized value T0- 9 minute |

### 2.3.4 Stored data (µg/m3)

| Address | Register | Access | Data | Description |
|---|---|---|---|---|
| 120 .. 121 | 121 .. 122 | R | float | Last memorized value T0 |
| 122 .. 123 | 123 .. 124 | R | float | memorized value T0- 1 minute |
| 124 .. 125 | 125 .. 126 | R | float | memorized value T0- 2 minutes |
| 126 .. 127 | 127 .. 128 | R | float | memorized value T0- 3 minutes |
| 128 .. 129 | 129 .. 130 | R | float | memorized value T0- 4 minutes |
| 130 .. 131 | 131 .. 132 | R | float | memorized value T0- 5 minute |
| 132 .. 133 | 133 .. 134 | R | float | memorized value T0- 6 minute |
| 134 .. 135 | 135 .. 136 | R | float | memorized value T0- 7 minute |
| 136 .. 137 | 137 .. 138 | R | float | memorized value T0- 8 minute |
| 138 .. 139 | 139 .. 140 | R | float | memorized value T0- 9 minute |

## 2.4 Cairsens PM

### 2.4.1 Measure

| Address | register | Access | Data | Description |
|---|---|---|---|---|
| 200 .. 201 | 201 .. 202 | R | float | PM10( µg/m3) |
| 202 .. 203 | 203 .. 204 | R | float | PM2.5( µg/m3 ) |
| 204 .. 205 | 205 .. 206 | R | float | Temp(°c) |
| 206 .. 207 | 207 .. 208 | R | float | Humidity(%) |

### 2.4.2 Stored data PM10 (µg/m3)

| Address | Register | Access | Data | Description |
|---|---|---|---|---|
| 300 .. 301 | 301 .. 302 | R | float | Last memorized value T0 |
| 302 .. 303 | 303 .. 304 | R | float | memorized value T0- 1 minute |

| | | | | |
|---|---|---|---|---|
| 304 .. 305 | 305 .. 306 | R | float | memorized value T0- 2 minutes |
| 306 .. 307 | 307 .. 308 | R | float | memorized value T0- 3 minutes |
| 308 .. 309 | 309 .. 310 | R | float | memorized value T0- 4 minutes |
| 310 .. 311 | 311 .. 312 | R | float | memorized value T0- 5 minute |
| 312 .. 313 | 313 .. 314 | R | float | memorized value T0- 6 minute |
| 314 .. 315 | 315 .. 316 | R | float | memorized value T0- 7 minute |
| 316 .. 317 | 317 .. 318 | R | float | memorized value T0- 8 minute |
| 318 .. 319 | 319 .. 320 | R | float | memorized value T0- 9 minute |

### 2.4.3 Stored data PM2.5 (µg/m3)

| Address | Register | Access | Data | Description |
|---|---|---|---|---|
| 320 .. 321 | 321 .. 322 | R | float | Last memorized value T0 |
| 322 .. 323 | 323 .. 324 | R | float | memorized value T0- 1 minute |
| 324 .. 325 | 325 .. 326 | R | float | memorized value T0- 2 minutes |
| 326 .. 327 | 327 .. 328 | R | float | memorized value T0- 3 minutes |
| 328 .. 329 | 329 .. 330 | R | float | memorized value T0- 4 minutes |
| 332 .. 331 | 331 .. 332 | R | float | memorized value T0- 5 minute |
| 332 .. 333 | 333 .. 334 | R | float | memorized value T0- 6 minute |
| 334 .. 335 | 335 .. 336 | R | float | memorized value T0- 7 minute |
| 336 .. 337 | 337 .. 338 | R | float | memorized value T0- 8 minute |
| 338 .. 339 | 339 .. 340 | R | float | memorized value T0- 9 minute |

### 2.4.4 Stored data Temp (°C)

| Address | Register | Access | Data | Description |
|---|---|---|---|---|
| 340 .. 341 | 341 .. 342 | R | float | Last memorized value T0 |
| 342 .. 343 | 343 .. 344 | R | float | memorized value T0- 1 minute |
| 344 .. 345 | 345 .. 346 | R | float | memorized value T0- 2 minutes |
| 346 .. 347 | 347 .. 348 | R | float | memorized value T0- 3 minutes |
| 348 .. 349 | 349 .. 350 | R | float | memorized value T0- 4 minutes |
| 352 .. 351 | 351 .. 352 | R | float | memorized value T0- 5 minute |
| 352 .. 353 | 353 .. 354 | R | float | memorized value T0- 6 minute |
| 354 .. 355 | 355 .. 356 | R | float | memorized value T0- 7 minute |
| 356 .. 357 | 357 .. 358 | R | float | memorized value T0- 8 minute |
| 358 .. 359 | 359 .. 360 | R | float | memorized value T0- 9 minute |

### 2.4.5 Stored data Humidity (%)

| Address | Register | Access | Data | Description |
|---|---|---|---|---|
| 360 .. 361 | 361 .. 362 | R | float | Last memorized value T0 |
| 362 .. 363 | 363 .. 364 | R | float | memorized value T0- 1 minute |
| 364 .. 365 | 365 .. 366 | R | float | memorized value T0- 2 minutes |
| 366 .. 367 | 367 .. 368 | R | float | memorized value T0- 3 minutes |
| 368 .. 369 | 369 .. 370 | R | float | memorized value T0- 4 minutes |
| 372 .. 371 | 371 .. 372 | R | float | memorized value T0- 5 minute |
| 372 .. 373 | 373 .. 374 | R | float | memorized value T0- 6 minute |
| 374 .. 375 | 375 .. 376 | R | float | memorized value T0- 7 minute |
| 376 .. 377 | 377 .. 378 | R | float | memorized value T0- 8 minute |
| 378 .. 379 | 379 .. 380 | R | float | memorized value T0- 9 minute |

# 3 Appendix

## 3.1 Glossary

| | |
|---|---|
| Address | address of location in memory map (WORD format => 2 bytes) |
| R | Read only parameter |
| R/W | Read / Write parameter |
| string | Character string |
| float | 32 bits floating point BIGENDIAN format |
| register | Word of 16 bits |


# Cairsens - UART Version

Communication Protocol

Measured data download

# Table of Contents

# 1 UART Port settings

| Baud rate | data bits | Parity | Stop bits | Flow control |
|---|---|---|---|---|
| 9600 | 8 | N | 1 | none |

# 2 Queries / answers structures between UART cairsens and host

The structure of the query / answer frame passing between the Cairsens and the host can be defined by a series of bytes, the number of which varying and being represented in hexadecimal.

The query frames have a fixed length and are structured as follows:
SYNC STX LG REF DATA CRC ETX

The answer frames have a fixed length and are structured as follows:
SYNC STX LG REF DATA END CRC ETX

Bytes definition is:
- SYNC = Synchro Word
- STX = Start Frame
- LG = Length of Data
- REF = Cairsens identification (Serial Number)
- DATA = [CMD+PARAM] (Series of bytes for command and parameters)
- END =End Frame
- CRC [2 bytes/LSB First]
- ETX
- LIFE = Life used

Synchronization and start frame bytes have the following values and constant number of bytes:
- SYNC = 1 byte = 0xFF
- STX = 1 byte = 0x02
- CRC = 2 bytes
- END = 2 bytes = LIFE 0xFF
- ETX = 1 byte = 0x03

# 3 Life

| Byte value | |
|---|---|
| 0x00 | the sensor can't return it's % life used |
| 0x80 | 0 % of life used (New sensor) |
| .. | .. |
| 0xC0 | 50 % of life used |
| .. | .. |
| 0xE0 | 75% life used |
| .. | .. |
| 0xFF | 100% life used ( end of life ) |

# 4 HeaderUart and TrailerUart definitions

In the following section of this document, the series of bytes representing SYNC STX LG and a part of CMD will be referred to as HeaderUart and will be defined by:

- HeaderUart = SYNC, STX, LG, 0x30, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06

In the same idea, the series of bytes representing END will be referred to as TrailerUart and will be defined by:

- TrailerUart = END CRC ETX

# 5 Cyclic redundancy checks

## 5.1 Compute

The CRC code is calculated by dividing the binary sequence representing the frame by the following polynomial:

$X^{16} + X^{12} + X^5 + 1$

## 5.2 Sample in c

```c
#include <stdio.h>

unsigned int FCRC( unsigned char Frame[],unsigned char lg)
{
  unsigned int Poly = 0x8408;
  unsigned int Crc;
  unsigned char j,i_bits,carry;
  Crc=0;
  for (j=0;j<lg; j++) {
    Crc = Crc ^ Frame[j];
    for ( i_bits = 0; i_bits < 8; i_bits++ ) {
      carry = Crc & 1;
      Crc = Crc/2;
      if(carry) {
        Crc = Crc ^ Poly;
      }
    }
  }
  return Crc;
}

int main(int argc, char* argv[])
{
    unsigned int i;

    unsigned char Frame[] = {0xFF, // Synchro Word
    0x02,// Start Frame
    0x13,// Length of Data
     0x30,0x01,0x02,0x03,0x04,0x05,0x06,
     0xff,0xff,0xff,0xff,0xff,0xff,0xff,0xff,
    0x12, // CMD
    0x00,0x00, // CRC [2 bytes/LSB First]
    0x03}; // End Frame
```

```
    unsigned int StartPos = 2; // start position CRC

    printf ( " Frame without CRC =" );
    for( i = 0 ; i < sizeof( Frame) ; i++ )
    {
        if( i > 0 ) putchar(',');
        printf ( " 0x%02X" , Frame[i] );
    }
    putchar('\n');

    i = FCRC ( &Frame[StartPos] , Frame[StartPos] - 2); // compute CRC without
CRC's bytes

    printf ( " CRC=0x%04X\n" , i );

    Frame[19] = i & 0xFF;
    Frame[20] = i >> 8;
    printf ( " CRC IN FRAME(LSB First)= 0x%02X 0x%02X\n" , Frame[19] ,
Frame[20]);


    printf ( " Frame with CRC= " );
    for( i = 0 ; i < sizeof( Frame) ; i++ )
    {
        if( i > 0 ) putchar(',');
        printf ( " 0x%02X" , Frame[i] );
    }
    putchar('\n');


    i = FCRC ( &Frame[StartPos] , Frame[StartPos] );  // check CRC
    if( i == 0 )
       printf ( " CRC OK\n");
    else
       printf ( " CRC ERROR\n" );
}

// output
//
//
// Frame without CRC = 0xFF, 0x02, 0x13, 0x30, 0x01, 0x02, 0x03, 0x04, 0x05,
0x06,0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0x12, 0x00, 0x00, 0x03
// CRC=0x88AF

// CRC IN FRAME(LSB First)= 0xAF 0x88

// Frame with CRC=  0xFF, 0x02, 0x13, 0x30, 0x01, 0x02, 0x03, 0x04, 0x05, 0x06,
0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0x12, 0xAF, 0x88, 0x03       //
CRC OK
```

# 6 REF definition

## 6.1 Product option

The REF 8 bytes represents the Cairsens reference (Serial number).
It allows to address individually and directly to a Cairsens, when in a network, several Cairsens are linked to a unique concentrator card.
The reference is included in every query with the Cairsens to allow an individual addressing, as only the concerned Cairsens will answer to the query.

FF FF FF FF FF FF FF FF is a generic address allowing to communicate with any product without knowing its reference.
of course in this situation, it has to be used with only one Cairsens linked to the host, to avoid any BUS corruption as all sensors will respond.

First byte is the product ID :

C = CAIRCLIP
D = CAIRSPM (new for particulates data and battery management)
H = CairClip H2S 200ppm ( for CAIRCLOUD )
M = CairClip H2S 20ppm ( for CAIRCLOUD )
L = CairClip H2S 2ppm ( for CAIRCLOUD )

The reference is an 8 bytes series coded as follows: XX YY ZZ AA 00 00 00 00

| | |
|---|---|
| XX | Product ID C=0x43 D=0x44 |
| YY | Gas identification |
| ZZ | Measure Range |
| AA | Interface Type |
| 00 00 00 00 | serial number |

## 6.2 Coefficient

For each sensor, you must use a multiplicative coefficient to get the final value :

| Sensor | Code | coefficient |
|---|---|---|
| CO 20ppm | COV | 1 |
| NMVOC 16ppm | CIV | 1 |
| H2S 1ppm | CHM | 4 |
| H2S 200ppm | CHV | 10 |
| H2S 20ppm | CHV or HHV | 1 |
| H2S 2ppm | CHV or MHV | 1 |
| NH3 25ppm | CAV or LHV | 100 |
| O3/NO2 1ppm | CCM | 4 |
| O3/NO2 250ppb | CCB | 1 |
| NO2 250ppb | CNB | 1 |
| SO2 1ppm | CSM | 4 |

## 6.3 Gaz Identification

Product reference second byte gives the gas identification ( NH3 in the example below )

| | | |
|---|---|---|
| REF | 8 bytes | 0x43 |
| | | 0x41 |
| | | 0x56 |
| | | 0x32 |
| | | 0x39 |
| | | 0x44 |
| | | 0x30 |
| | | 0x35 |

List of gases

| ASCII | HEX | DATA |
|---|---|---|
| A | 0x41 | Ammonia(NH3) |
| B | 0x42 | Benzene |
| C | 0x43 | Ozone(O3) and Nitrogen Dioxide(NO2) |
| D | 0x44 | Dust |
| E | 0x45 | CO2 |
| F | 0x46 | Formaldehyde(CH2O) |
| G | 0x47 | CH4 |
| H | 0x48 | Hydrogen Sulfide(H2S) |
| I | 0x49 | NMVOC |
| L | 0x4C | Chlorine(Cl2) |
| N | 0x4E | Nitrogen Dioxide(NO2) |
| O | 0x4F | CO |
| P | 0x50 | Tetrachloroethylene |
| T | 0x54 | Toluene |
| S | 0x53 | SO2 |

## 6.4 Measure range

| ASCII | HEX | Range |
|---|---|---|
| B | 0x42 | 0-250 ppb |
| M | 0x4D | 0-1 ppm |
| V | 0x56 | 0-20 ppm<br>for H2S 0-2 ppm, 0-20 pm or 0-200 ppm<br>for NH3 0-25 ppm |
| P | 0x50 | PACKET data block for CAISPM |

## 6.5 Interface type

| HEX | Interface |
|---|---|

| | |
|---|---|
| 0x01 | USB |
| 0x02 | UART |

## 6.6 Example

- Query:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x13 |
| | 7 bytes | 0x30 |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| CMD | 1 byte | 0x1C |
| CRC | 2 bytes | 0xD1 |
| | | 0x61 |
| ETX | 1 byte | 0x03 |

- Answer:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x1D |
| | 7 bytes | 0x2C |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0x43 |
| | | 0x48 |
| | | 0x56 |
| | | 0x02 |
| | | 0x00 |
| | | 0x00 |
| | | 0x10 |
| | | 0x08 |
| RSP | 1 byte | 0x1D |
| Product reference | 2 bytes | 0x43 |
| | | 0x48 |
| Product option | 1 byte | 0x56 |
| Product internal ID | 5 bytes | 0x02 |
| | | 0x00 |
| | | 0x00 |
| | | 0x10 |
| | | 0x08 |
| END | 2 bytes | 0x80(LIFE) |
| | | 0xFF |
| CRC | 2 bytes | 0x06 |
| | | 0xBA |
| ETX | | 0x03 |

REF: CHV0200001008

# 7 Reading of the instant value of the Cairsens (GetValue)

## 7.1 Query

This structure allows the reading of the instant value of the Cairsens
Query:

- HeaderUart REF CMD CRC ETX
- Command byte CMD = 0x12

## 7.2 Answer

HeaderUart REF RSP PARAM=0xXX CRC TrailerUart
- Answer byte RSP = 0x13
- Instant value byte PARAM (see below)

The last value (last data stored) is expressed as follows:
- Parameter 1: 1 data

## 7.3 Example 1 byte by value

- Query:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x13 |
| | 7 bytes | 0x30 |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| CMD | 1 byte | 0x12 |
| CRC | 2 bytes | 0xAF |
| | | 0x88 |
| ETX | 1 byte | 0x03 |

- Answer:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x16 |
| | 7 bytes | 0x2C |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0x43 |
| | | 0x41 |
| | | 0x56 |
| | | 0x32 |
| | | 0x39 |
| | | 0x44 |
| | | 0x30 |
| | | 0x35 |
| RSP | 1 byte | 0x13 |
| Measure | 1 byte | 0xD1 |
| END | 2 byte | 0x00(LIFE) |
| | | 0xFF |
| CRC | 2 bytes | 0x70 |
| | | 0xFB |
| ETX | 1 byte | 0x03 |

here the value is 0xD1 = 209

it's a cairsens CAV ( NH3 25ppm ) : measure = 209*100 = 20900pbb = 20.9 ppm

for a cairsens CHM ( H2S 1ppm ) : measure = 209*4 = 836pbb = 0.836 ppm
for a cairsens CCM ( O3 1ppm ) : measure = 209*4 = 836pbb = 0.836 ppm
for a cairsens CSM ( SO2 1ppm ) : measure = 209*4 = 836pbb = 0.836 ppm

## 7.4 Example 2 bytes by value

- Query:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x13 |
| | 7 bytes | 0x30 |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| CMD | 1 byte | 0x12 |
| CRC | 2 bytes | 0xAF |
| | | 0x88 |
| ETX | 1 byte | 0x03 |

- Answer:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x17 |
| | 7 bytes | 0x2C |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0x43 |
| | | 0x49 |
| | | 0x56 |
| | | 0x32 |
| | | 0x33 |
| | | 0x33 |
| | | 0x30 |
| | | 0x33 |
| RSP | 1 byte | 0x13 |
| | 2 bytes | 0xB8 |
| | | 0x2E |
| END | 2 byte | 0x00(LIFE) |
| | | 0xFF |
| CRC | 2 bytes | 0xF3 |
| | | 0x8D |
| ETX | 1 byte | 0x03 |

it's a cairsens CIV ( 2 bytes by value )
measure = ( 0x2E * 256 + 0xB8 ) = 11960 ppb = 11.960 ppm

for a cairsens H2S 200ppm the value is: 11960 * 10 = 119600ppb = 119.6 ppm

# 8 GetDownload structure for cairsens (Stored data download)

## 8.1 Query

Command byte is CMD = 0x0C

The parameter allowing the data download PARAM is built on a byte which value can vary and refer to several periods to download:

- 0x00: 10 successive points of measurement
- 0x01: 96 successive points of measurement for 1 byte by value , 48 successive points of

measurement for 2 byte by value
- 0x02: send 7 answer of 96 successive points of measurement for 1 byte by value , 48 successive points of measurement for 2 byte by value
- 0x03: send 30 answers of 96 successive points of measurement for 1 byte by value , 48 successive points of measurement for 2 byte by value
- 0x04: send 60 answers of 96 successive points of measurement for 1 byte by value , 48 successive points of measurement for 2 byte by value
- 0x05: send 90 answers of 96 successive points of measurement for 1 byte by value , 48 successive points of measurement for 2 byte by value
- 0x06: send 240 answers of 96 successive points of measurement for 1 byte by value , 48 successive points of measurement for 2 byte by value
- 0x07: send 300 answers of 96 successive points of measurement for 1 byte by value , 48 successive points of measurement for 2 byte by value

This number of points of measurement is valid for a sampling factory configured (meaning one measurement per minute)

## 8.2 Answer

HeaderUart REF RSP PARAM TrailerUart

Answer byte is RSP = 0x0D
- Information + requested data = PARAM (see below)

PARAM holds various information about Cairsens' status in addition to the requested data.

This sequence of information consists of the 10 following parameters:
- Parameter 1 - 1 byte: number of the RS232 exchange frame, coded in hexadecimal (from 0x01 to 0xFF)
- Parameter 2 - 1 byte: total number of RS232 exchange frames, coded in hexadecimal (from 0x01 to 0xFF)
- Parameter 3 - 2 bytes: not used
- Parameter 4 - 1 byte: not used
- Parameter 5 – 1 byte: not used
- Parameter 6 – 1 byte: not used
- Parameter 7 – 1 byte: not used
- Parameter 8 – 1 byte: not used
- Parameter 9 – 2 bytes: not used
- Parameter 10 – 96 bytes:

  1 byte by value : 96 data of 1 byte each = 96 bytes of pollutant level data
  2 bytes by value : 48 data of 2 byte each = 96 bytes of pollutant level data

## 8.3 Example 10 minutes data 1 byte by value

- Query:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x14 |
| | 7 bytes | 0x30 |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| CMD | 1 byte | 0x0C |
| PARAM | 1 byte | 0x00 |
| CRC | 2 bytes | 0x63 |
| | | 0xA8 |
| ETX | 1 byte | 0x03 |

- Answer:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x2A |
| | 7 bytes | 0x2C |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0x43 |
| | | 0x48 |
| | | 0x4D |
| | | 0x02 |
| | | 0x09 |
| | | 0x14 |
| | | 0x00 |
| | | 0x22 |
| RSP | 1 byte | 0x0D |
| number of the RS232 exchange frame, coded in hexadecimal | 1 byte | 0x01 |
| total number of RS232 exchange frames, coded in hexadecimal | 1 byte | 0x01 |
| not used | 2 bytes | 0x00 |
| | | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 2 bytes | 0x00 |
| | | 0x00 |
| value n°1(oldest) | 1 byte | 0x00 |
| value n°2 | 1 byte | 0x00 |
| value n°3 | 1 byte | 0x00 |
| value n°4 | 1 byte | 0x00 |
| value n°5 | 1 byte | 0x00 |
| value n°6 | 1 byte | 0x00 |
| value n°7 | 1 byte | 0x00 |
| value n°8 | 1 byte | 0x00 |
| value n°9 | 1 byte | 0x00 |
| value n°10(recent) | 1 byte | 0x00 |
| END | 2 bytes | 0x00(LIFE) |
| | | 0xFF |
| CRC | 2 bytes | 0x4D |
| | | 0x90 |

| | | |
|---|---|---|
| ETX | 1 byte | 0x03 |

for a cairsens CAV ( NH3 25ppm ) : measure in ppb = value*100
for a cairsens CHM ( H2S 1ppm ) : measure in ppb = value*4
for a cairsens CCM ( O3 1ppm ) : measure in ppb = value*4
for a cairsens CSM ( SO2 1ppm ) : measure in ppb = value*4

## 8.4 Example 10 minutes data 2 bytes by value

Download of 10 minutes data => GetDownload query (0x00):

- Query:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x14 |
| | 7 bytes | 0x30 |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| | | 0xFF |
| CMD | 1 byte | 0x0C |
| PARAM | 1 byte | 0x00 |
| CRC | 2 bytes | 0x63 |
| | | 0xA8 |
| ETX | 1 byte | 0x03 |

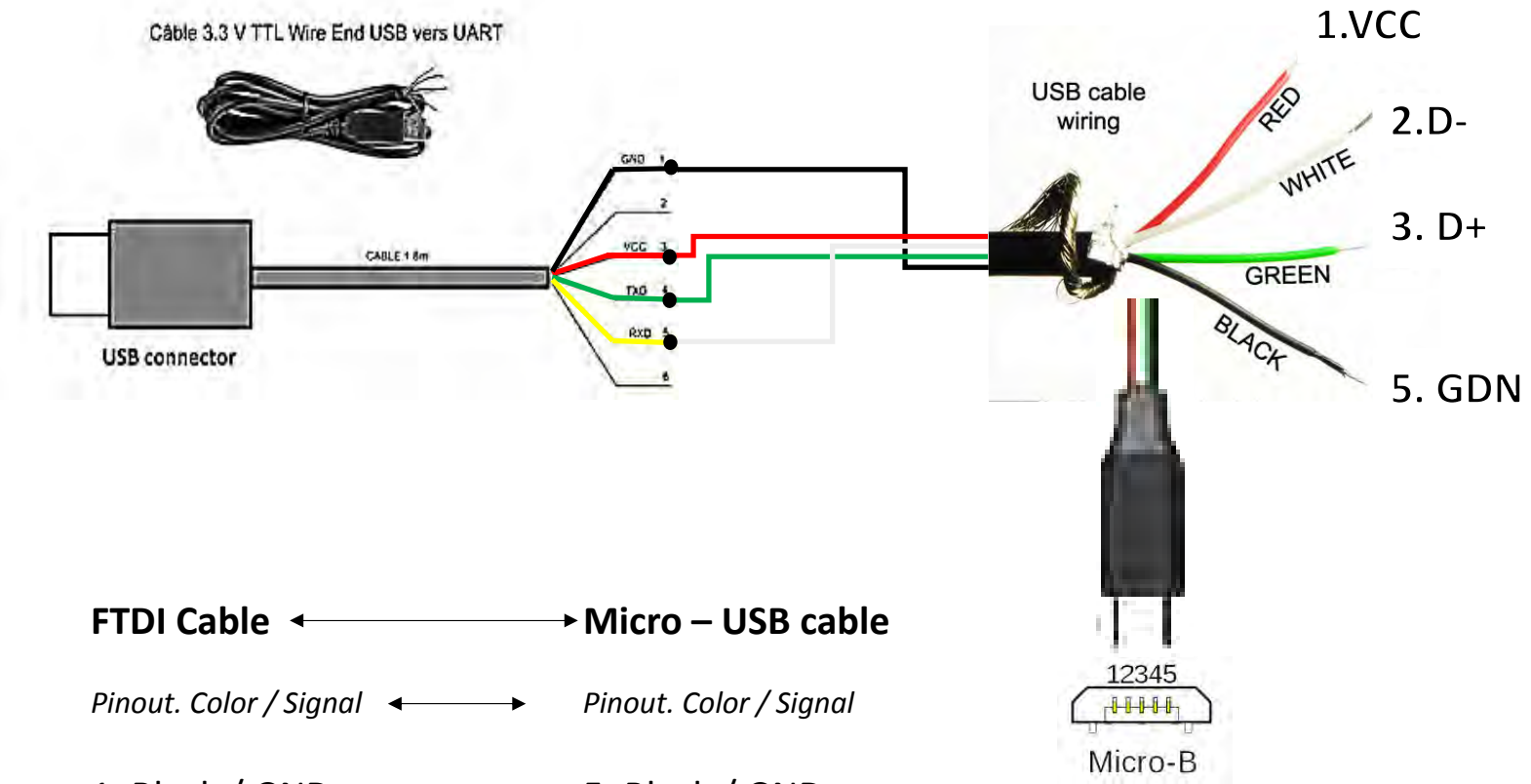
- Answer:

| | | |
|---|---|---|
| SYNC | 1 byte | 0xFF |
| STX | 1 byte | 0x02 |
| LG | 1 byte | 0x34 |
| | 7 bytes | 0x2C |
| | | 0x01 |
| | | 0x02 |
| | | 0x03 |
| | | 0x04 |
| | | 0x05 |
| | | 0x06 |
| REF | 8 bytes | 0x43 |
| | | 0x49 |
| | | 0x56 |
| | | 0x02 |
| | | 0x33 |
| | | 0x33 |
| | | 0x00 |
| | | 0x33 |
| RSP | 1 byte | 0x0D |
| number of the RS232 exchange frame, coded in hexadecimal | 1 byte | 0x01 |
| total number of RS232 exchange frames, coded in hexadecimal | 1 byte | 0x01 |
| not used | 2 bytes | 0x00 |
| | | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 1 byte | 0x00 |
| not used | 2 bytes | 0x00 |
| | | 0x00 |
| value n°1(oldest) | 2 bytes | 0xE8 |
| | | 0x2B |
| value n°2 | 2 bytes | 0x60 |
| | | 0x2C |
| value n°3 | 2 bytes | 0x1A |
| | | 0x2C |
| value n°4 | 2 bytes | 0x8E |
| | | 0x2B |
| value n°5 | 2 bytes | 0x8E |
| | | 0x2B |
| value n°6 | 2 bytes | 0x8E |
| | | 0x2B |
| value n°7 | 2 bytes | 0x06 |
| | | 0x2C |

| | | |
|---|---|---|
| value n°8 | 2 bytes | 0x60 |
| | | 0x2C |
| value n°9 | 2 bytes | 0xDE |
| | | 0x2B |
| value n°10(recent) | 2 bytes | 0xE8 |
| | | 0x2B |
| END | 2 bytes | 0x00(LIFE) |
| | | 0xFF |
| CRC | 2 bytes | 0x69 |
| | | 0x0D |
| ETX | 1 byte | 0x03 |

value 1 : 0x2B *256 + 0xE8 = 11240 ppb
value 2 : 0x2C *256 + 0x60 = 11360 ppb
value 3 : 0x2C *256 + 0x1A = 11290 ppb
value 4 : 0x2B *256 + 0x8E = 11150 ppb
value 5 : 0x2B *256 + 0x8E = 11150 ppb
value 6 : 0x2B *256 + 0x8E = 11150 ppb
value 7 : 0x2C *256 + 0x06 = 11270 ppb
value 8 : 0x2C *256 + 0x60 = 11360 ppb
value 9 : 0x2B *256 + 0xDE = 11230 ppb
value 10: 0x2B *256 + 0xE8 = 11240 ppb

for a cairsens H2S 200ppm : measure 1 = value1*10 = 112400 ppb = 112.4 ppm




| **FTDI Cable** | ⟷ | **Micro – USB cable** |
|---|---|---|
| *Pinout. Color / Signal* | ⟷ | *Pinout. Color / Signal* |
| 1. Black / GND | ⟷ | 5. Black / GND |
| 3. Red / VCC | ⟷ | 1. Red / VCC |
| 4. Orange / TXD | ⟷ | 3. Green / D+ |
| 5. Yellow / RXD | ⟷ | 2. White / D- |