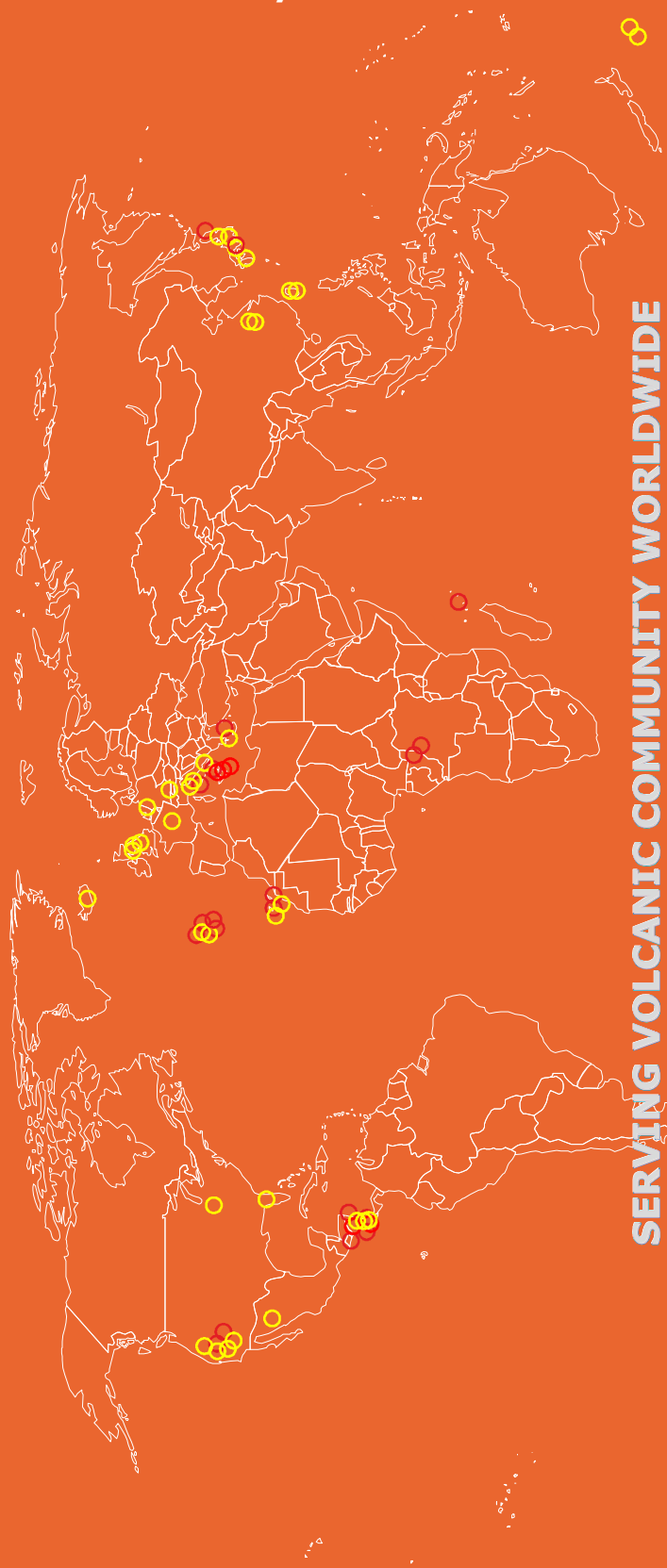
Continuous Monitoring Flux Station

Handbook

Release 3.3
January 2017



SERVING VOLCANIC COMMUNITY WORLDWIDE

USU SAN, MASAYA, POAS, TEIDE, CUMBRE VEJA, ETNA, STROMBOLI, CAMPI FLEGREI, VESUVIUS, SANTORINI.
Tokyo University, Kyoto University, PennState University, U.S.G.S., ITER, Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano

FOGO, FURNAS, TERCEIRA, MAMMOTH Horseshoe Lake, San MIGUEL, San VINCENTE, San SALVADOR, Santa ANA, MOUNUN , NYOS.
Açores University, Université Libre de Bruxelles, University of Florida, Consiglio Nazionale delle Ricerche, Colima University, University of Michigan, Santorini Volcano Observatory

Systems
WEST
ITALY

Warranty information

Each West Systems instrument is warranted by West Systems Srl to be free from defects in material and workmanship under normal operating conditions; however, West Systems's sole obligation under this warranty shall be to repair or replace any part of the instrument which West Systems 's examination discloses to have been defective in material or workmanship without charge and only under the following conditions, which are:

1. The defects are called to the attention of West Systems in writing within one year after the shipping date of the instrument.

2. The instrument has not been maintained, repaired or altered by anyone who was not approved by West Systems.

3. The instrument was used in the normal, proper, and ordinary manner and has not been abused, altered, misused, neglected, involved in an accident or damaged by act of God or other casualty.

4. The purchaser, whether it is a distributor or direct customer of West Systems or a distributor's customer, packs and ships or delivers the instrument to West Systems (at West Systems 's main office in Pontedera (PI) Italy, within 30 days after West Systems has received written notice of the defect. Unless other arrangements have been made in writing, transportation to West Systems is at customer expense.

5. No-charge repair parts may be sent at West Systems 's sole discretion to the purchase for installation by purchaser.

6. West Systems 's liability is limited to repair or replace any part of the instrument without charge if West Systems 's examination disclosed that part to have been defective in material or workmanship.

7. Before returning an instrument for repair, the Customer must obtain a Return Goods Authorization (RGA), writing to support@westsystems.com and providing information about part number, serial number and description of the issue. Instructions on packaging and shipping will be e-mailed back to the Customer. The company-issued RGA number must be displayed on the return package.

The laws of some locations may not allow the exclusion or limitation on implied warranties or on incidental or consequential damages, so the limitations here in may not apply directly. This warranty gives you specific legal rights, and you may already have other rights which vary from location to location. All warranties that apply, whether included by this contract or by law, are limited to the time period of this warranty which is a twelve-month period commencing from the date the instrument is shipped to the customer.

Responsibility

West shall not be held responsible for any damage to the equipment or for any physical injury or death resulting in whole or in part from the inappropriate use, installation or storage of the equipment, which is the result of not complying with the instructions and warnings, and/or with the standards and regulations in force.

READ THESE INSTRUCTIONS CAREFULLY BEFORE THE FIRST USAGE.

IMPORTANT INFORMATION FOR CORRECT DISPOSAL OF THE PRODUCT IN ACCORDANCE WITH EC DIRECTIVE 2002/96/EC.

At the end of its working life, the product must not be disposed of as urban waste. It must be taken to a special local authority differentiated waste collection centre or to a dealer providing this service. Disposing of a household appliance separately avoids possible negative consequences for the environment and health deriving from inappropriate disposal and enables the constituent materials to be recovered to obtain significant savings in energy and resources. As a reminder of the need to dispose of household appliances separately, the product is marked with a crossed-out wheeled dustbin.

If your equipment requires maintenance in Italy

Before shipping the instrument back to Italy, remember:

- When you ask your shipping agent to send the instrument to Italy check that on the Air Waybill the Airport of destination is Pisa. Any other airport of destination creates a lot of problems in delivering the items (delay, costs, custom problems, etc).

!- Check that the Company your shipping agent chooses lands in Galileo Galilei Airport in Pisa. If not, ask your shipping agent to change the Company or send the items by DHL or UPS or FedEx

- Mark each item with a serial number, if not already present, and write this number on the document (proforma or original invoice or item list) where you list the parts you are sending back to Italy.

- Specify a correct value of the parts you are sending back in the documents mentioned above. *Pay attention to these rules because Custom law in Italy is very complicated and probably different from your Country.*

If you follow these suggestions everything will be easier for you and for us.

Index

1.Introduction

1.1 Safety information

Carbon dioxide is a **toxic gas**. Carbon dioxide is colourless, odourless, tasteless and is heavier than air. Air concentration higher than 5000 ppm can cause dizziness, shortness of breath, rapid pulse. Higher concentrations of carbon dioxide can be **lethal**. Diffuse carbon dioxide fluxes are normally related to anomalous carbon dioxide air concentration. The user must verify the safety conditions before entering dangerous areas using specific and approved instrumentation.

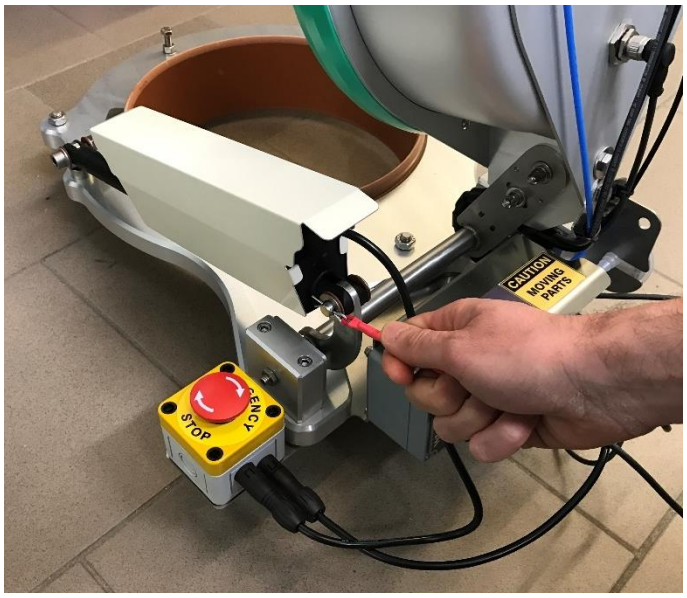
The flux meter described in this manual is designed to measure diffuse emission of soil gases and CANNOT be used for different purposes, especially if related with safety.

The chamber contains moving parts that may cause harm to people or things. When the chamber is opening or closing, a risk of pinching is present.

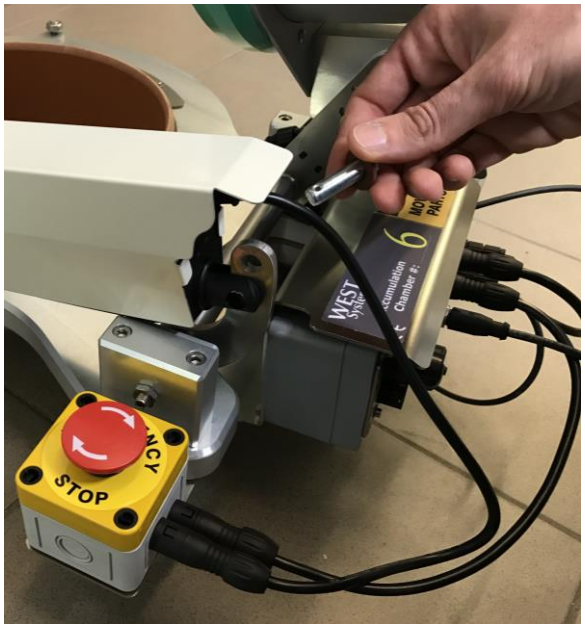
Use the greatest attention when operating in the chamber range. Do not touch the chamber when the motor is running. When the flux station is ON, the chamber will open and close automatically at regular intervals.

In case of emergency:

1) Press the emergency button to immediately stop the motion of the chamber.
2) Pull the red cord as shown in the picture. Pulling the cord will remove the retaining clip.



3) Once the retaining clip is removed, remove the clevis pin to free the chamber axle from the motor.



The instrument and the electronic accessories are NOT designed to work in explosion risk areas.

1.2 Hints

About installation

Before starting the installation of the flux station is better to install the WS-Scada software suite on the computer. The on-field installation is described on chapter 2.

About soil fluxes

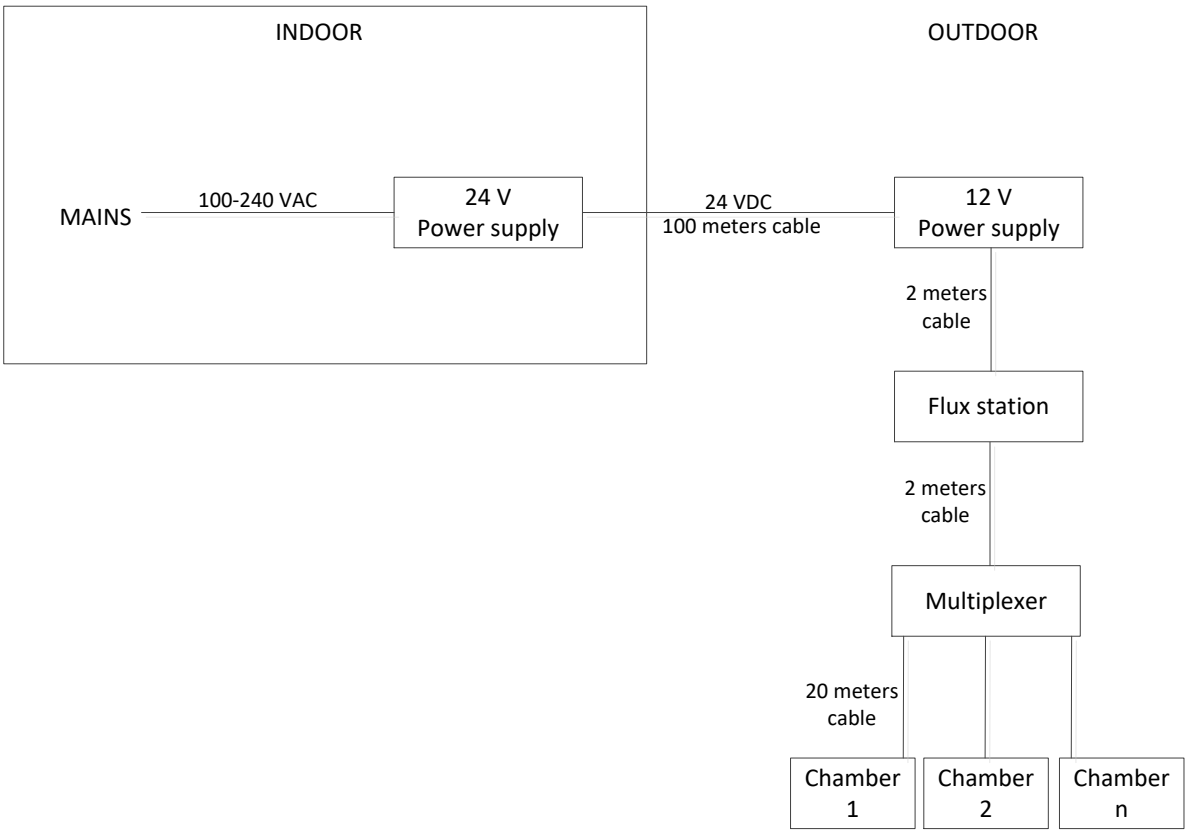
The flux phenomena can be perturbated by the installation, because of digging the soil, hammering, placing the collar.
The "normal" regime will be restored in few days.

2. Power supply

The power supply is composed by 3 components:
- A 24 V power supply, to be connected directly to the AC socket.
- A 100 meters extension cable
- A 12 V power supply

The 12 V power supply gives power directly to the flux station, which is equipped with an ON/OFF switch, internal to the case.
Once the flux station is switched ON, the whole system is powered. The multiplexer unit and the chambers are turned on by the flux station according to the sampling schedule.

The configuration is schematized by the following diagram.



This hybrid 24V/12V solution permits having the flux station very far (100 meters) from the primary power source, while not bringing an AC cable directly to the field.

24 V power supply specifications
Order code: Meanwell HEP-150-24A
Protection grade: IP65
Input: 100-240 VAC, 50/60Hz
DC Voltage: 24 V
Rated current: 6.3 A

2 Power supply

Rated power: 151.2 W
Built-in active PFC function
Working temperature: -55 ~ +70 °C
Working humidity: 20 ~ 95% RH non-condensing
Protections: Short circuit / Overload / Over voltage / Over temperature

24 V Power supply

Extension cable specifications
Section: 2 x 2.5 mm^2
Length: 100 meters

12 V power supply specifications
Order code: Meanwell SD-100B-12
Input: 19-36 VDC
DC Voltage: Adjustable 11-16 VDC
Rated current: 8.5 A
Rated power: 102 W
Working temperature: -10 ~ +60 °C
Working humidity: 20 ~ 90% RH non-condensing

The 12 V power supply is enclosed in a waterproof Polypropylene case.

12 V Power supply

Input connector: Bulgin 6000, 2 Contacts, Male

Input connector Pinout	
Pin	**Signal**
1	GND
2	+24 V

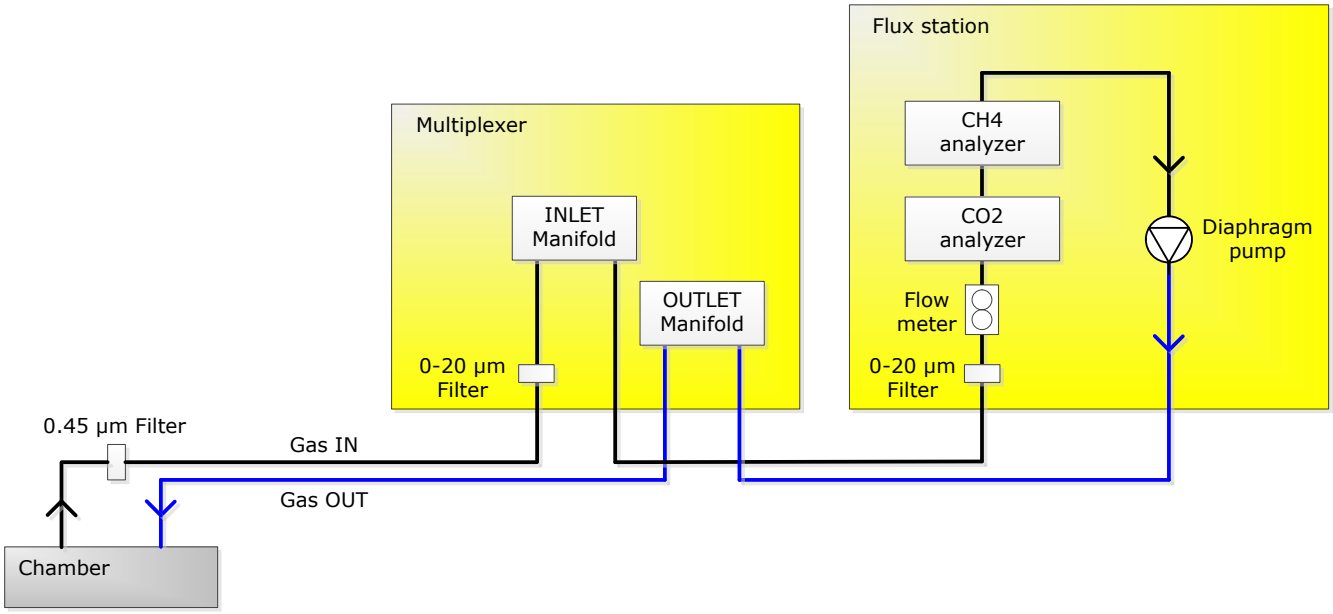
Output connector: Amphenol Eco-Mate, 3+PE, Female

Output connector Pinout	
Pin	**Signal**
1	+12 V
2	GND
3	NC
4	NC

2 Power supply

3. Pneumatic circuit

The gas circuit of the systems is schematized by the following diagram:



The colour of the tubes used in the whole system is codified as:

- **Gas supply** (from the chamber to the station): solid black or transparent white tube.
- **Gas return** (from the station to the chamber): solid blue or transparent blue tube.

3.1 Tubes

3 types of tube are used to realize the gas sampling line:

- Type A

Where is used: connection from the chamber to the multiplexer
Material: Polyurethane Polyether
External diameter: 4 mm
Internal diameter: 2.5 mm
Max operating pressure: 12 Bar
Minimum bending radius: 15 mm
Manufacturer: Parker/Legris
Ordering code: 1025U

- Type B

Where is used: multiplexer internal connections.
Material: Polyurethane
External diameter: 4 mm
Internal diameter: 2.5 mm
Max operating pressure: 8 Bar
Minimum bending radius: 10 mm
Manufacturer: SMC
Ordering code: TU0425

- Type C

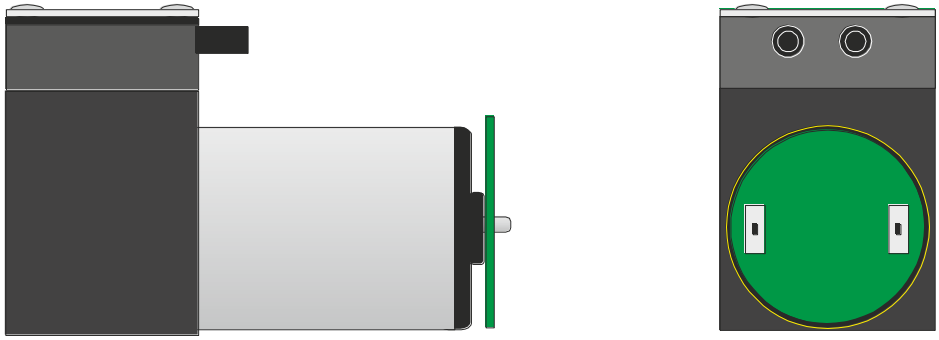
Where is used: connection from the multiplexer to the flux station, flux station internal connections, multiplexer internal connections.
Material: Polyurethane
External diameter: 6 mm
Internal diameter: 4 mm
Max operating pressure: 8 Bar
Minimum bending radius: 15 mm
Manufacturer: SMC
Ordering code: TU0604

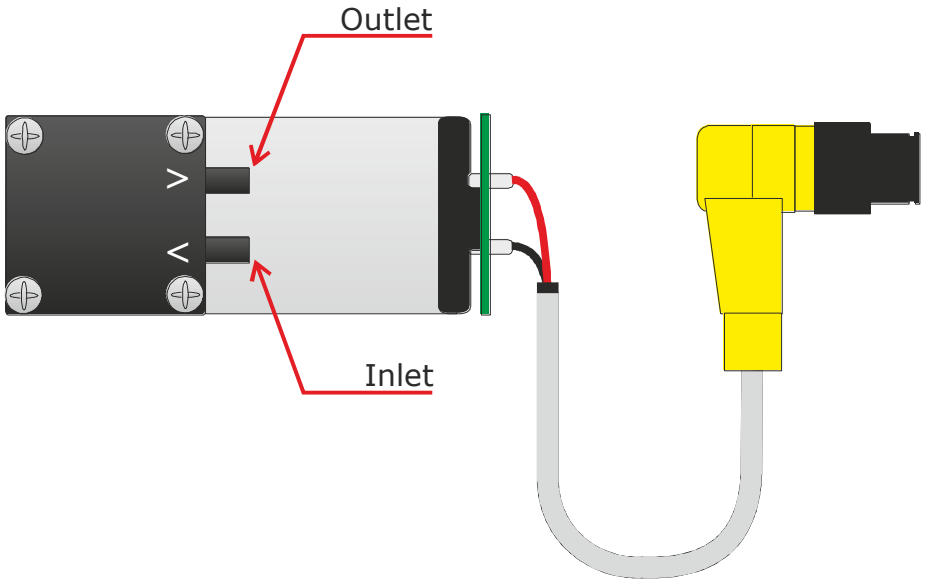
3.2 Filters

The PTFE membrane filters are permeable to gases and water vapour and are impermeable to liquid water and dust particles. The use of the filters protects the gas detectors and the other pneumatic parts. Please check the status of the filters every month.

Two types of filters are used:
- 25 mm diameter, 0.20 µm PTFE membrane
  Model: Cole-Parmer 2915-20 or equivalent
- 50 mm diameter, 0.45 µm PTFE membrane
  Model: Cole-Parmer 2915-30 or equivalent

3.3 Pump





Pin	Signal
1	+12V
2	NC
3	NC
4	GND

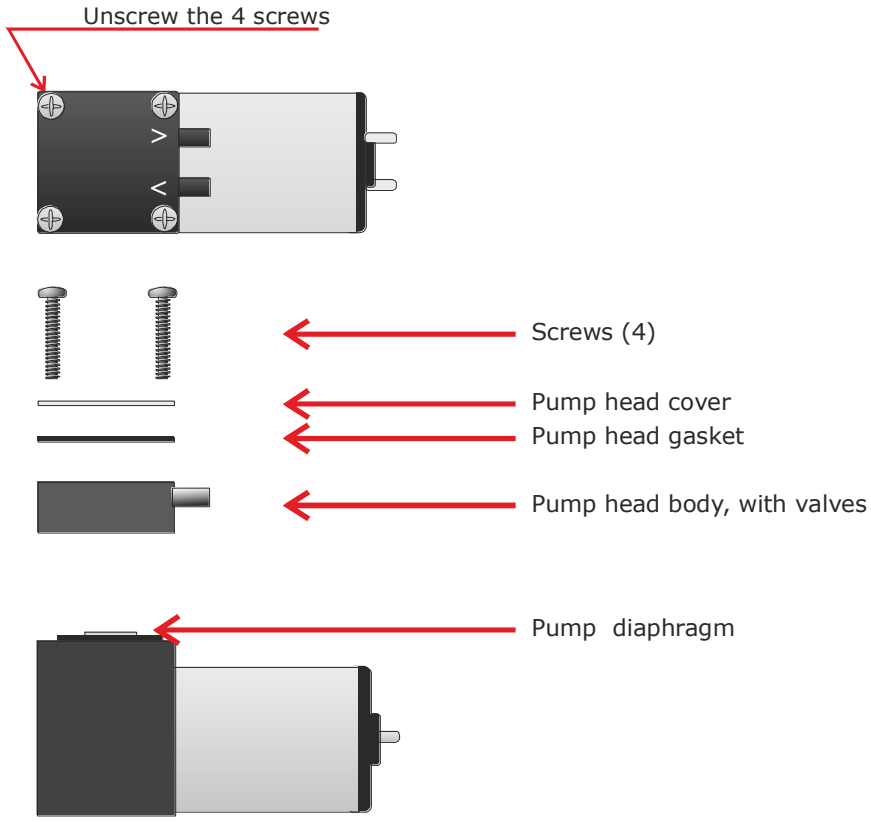
Pump specifications
Rated flow: 1200 SCCM (Standard cubic centimeter per minute)
Power supply 150 mA @ 12 Volts

Manufacturer: KNF
Ordering code: NMP830KNDC
Pneumatic fittings diameter: 4 mm

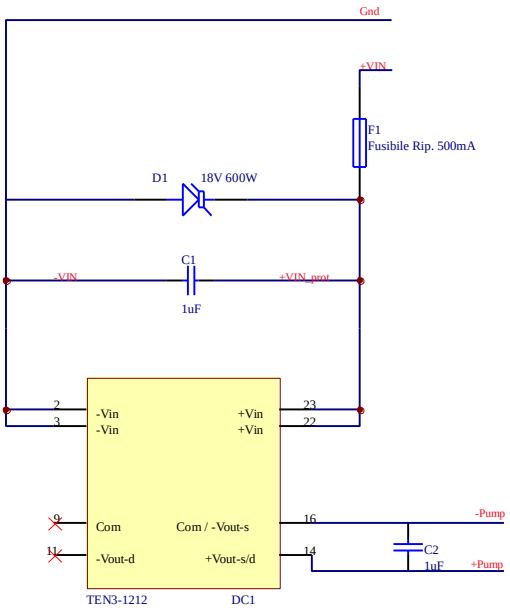
Pump maintenance
The pump efficiency can be affected by deposits of dust or water. When necessary it's possible to clean the pump:

- Disassemble the pumping head
- Clean the diaphragm, the washer, and the valves using a compressed air flow.

- Reassemble the head.



Pump stabilizer scheme



4. On-field Installation

4.1 Power supply

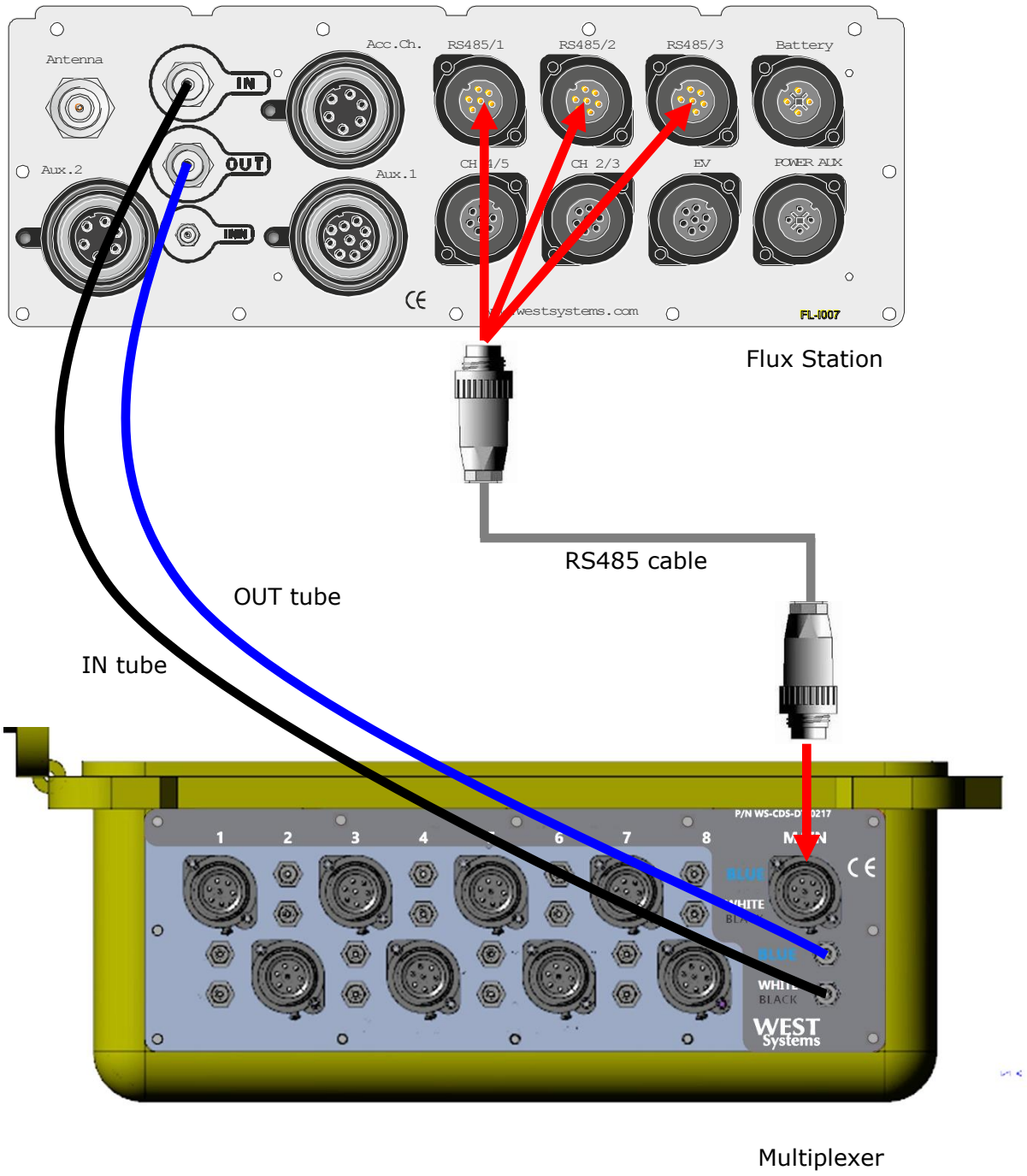
Connect the power supply following the diagram in chapter 2:

a) Put the 24 V power supply in position, near a 100-240 VAC socket. Wait to connect it to the mains until the whole system is installed. Although the power supply has a IP65 protection grade, we suggest installing it indoor.
b) Connect the extension cable 2-pole connector to the 24 V power supply.
c) Unroll the extension cable and place it on the ground.
d) Place the 12 V power supply and connect the extension cable 4-pole connector.
e) Connect the Flux station to the 12 V power supply using the power supply cord (code ASTPSC00).
f) Finally, you can connect the 24 V power supply to the mains. The flux station is still OFF until the internal ON/OFF switch is turned on.

4.2 Flux station and multiplexer

Connect the flux station to the multiplexer as described in the following diagram.

4 On-field installation



1) Connect the station to the multiplexer using the RS485 cable.
   On the flux station, any of the 3 available RS485 sockets can be used.
   On the multiplexer, connect to the MAIN socket.
   Push the plug into the socket and tighten the ring. Make sure the plug is fully inserted.

2) Using the black tube, connect the station INLET (upper joint, labelled as *IN*) to the multiplexer INLET (lower joint, labelled as *WHITE/BLACK*).
   The connection is secured by a ring nut:
   a) Make sure the ring nut is installed on the tube before inserting it.
   b) Push the tube completely into the metal fitting.
   c) Finally, tighten the ring nut.

3) Using the blue tube, connect the station OUTLET (lower joint, labelled as *OUT*) to the multiplexer OUTLET (lower joint, labelled as *BLUE*). The connection is secured by a ring nut.
    a) Make sure the ring nut is installed on the tube before inserting it.
    b) Push the tube completely into the metal fitting.
    c) Finally, tighten the ring nut.

4.3 Chamber

Each chamber is contained in a transport case along with the connecting cable and hoses, the soil temperature probe and the soil moisture probe.

Both the IN-OUT tubes and the signal cable are enclosed in a hose sleeve. The sleeve provides protection against mechanical torsion and from direct solar radiation. Also, the installation is simplified as only one hose has to be deployed to the ground.

Despite the protection, please be careful not the bend the tubes with an angle of more than approximately 75 mm radius. That could create a permanent bottleneck in the tube and therefore a decrease of the flow.

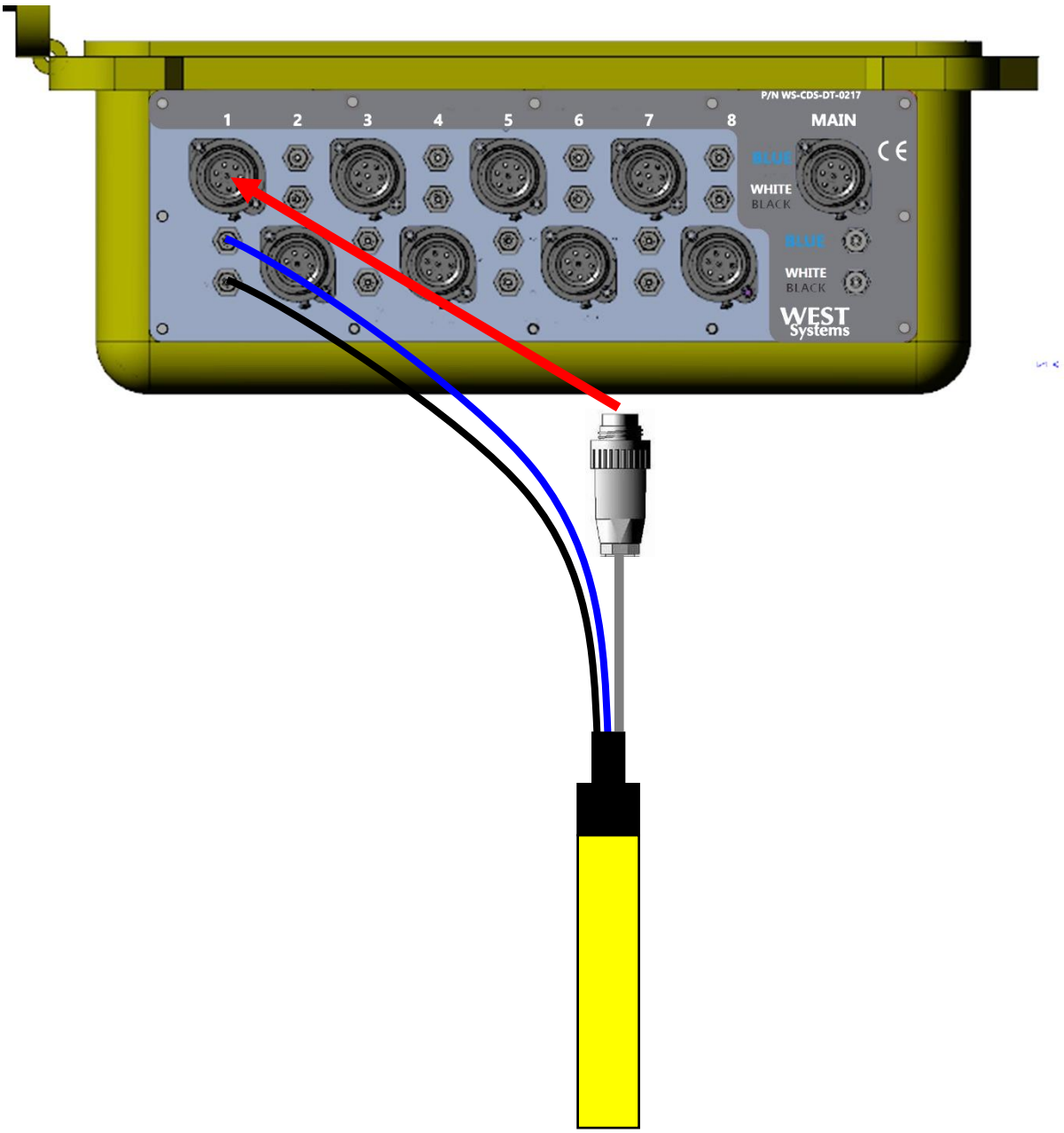
Note: all chambers and all sleeves are labelled with a number from 1 to 16 (the maximum number of chamber managed by the multiplexer). The label is applied with the only purpose of an easier maintenance of the system. The hardware and configuration of all the chambers and all the sleeves are the same.
For example, connecting the chamber labelled as [AC 1] to the port #2 of the multiplexer will not affect the normal operation of the system. At the time scheduler for chamber #2, the multiplexer will activate the port #2. The chamber connected to the port #2 (in the example [AC 1]) will perform the flux measurement. The flux station is not aware of which chamber is connected to the selected multiplexer port.

1) Starting from the [AC 1], remove the chamber and the relative sleeve from the transport case. Place the chamber approximately in the final position. The cables are 20 meters long.

2) The sleeve sides are labelled as “AC SIDE” (accumulation chamber side) and “MUX SIDE” (multiplexer side). The only difference is that the chamber side has longer cables for an easier connection.

Note: the hose sleeves are shipped by West Systems with the INLET and OUTLET tubes joined between each other with a small piece of silicone tube. The reason is to avoid the entering of dirt inside the tubes during the transport and installation. Remove the silicone tube just before the final connection to the chamber or the multiplexer.
Please re-insert the silicon tube whenever the tubes are disconnected and moved.

Connect the "MUX SIDE" of the sleeve to the multiplexer as indicated in the figure:



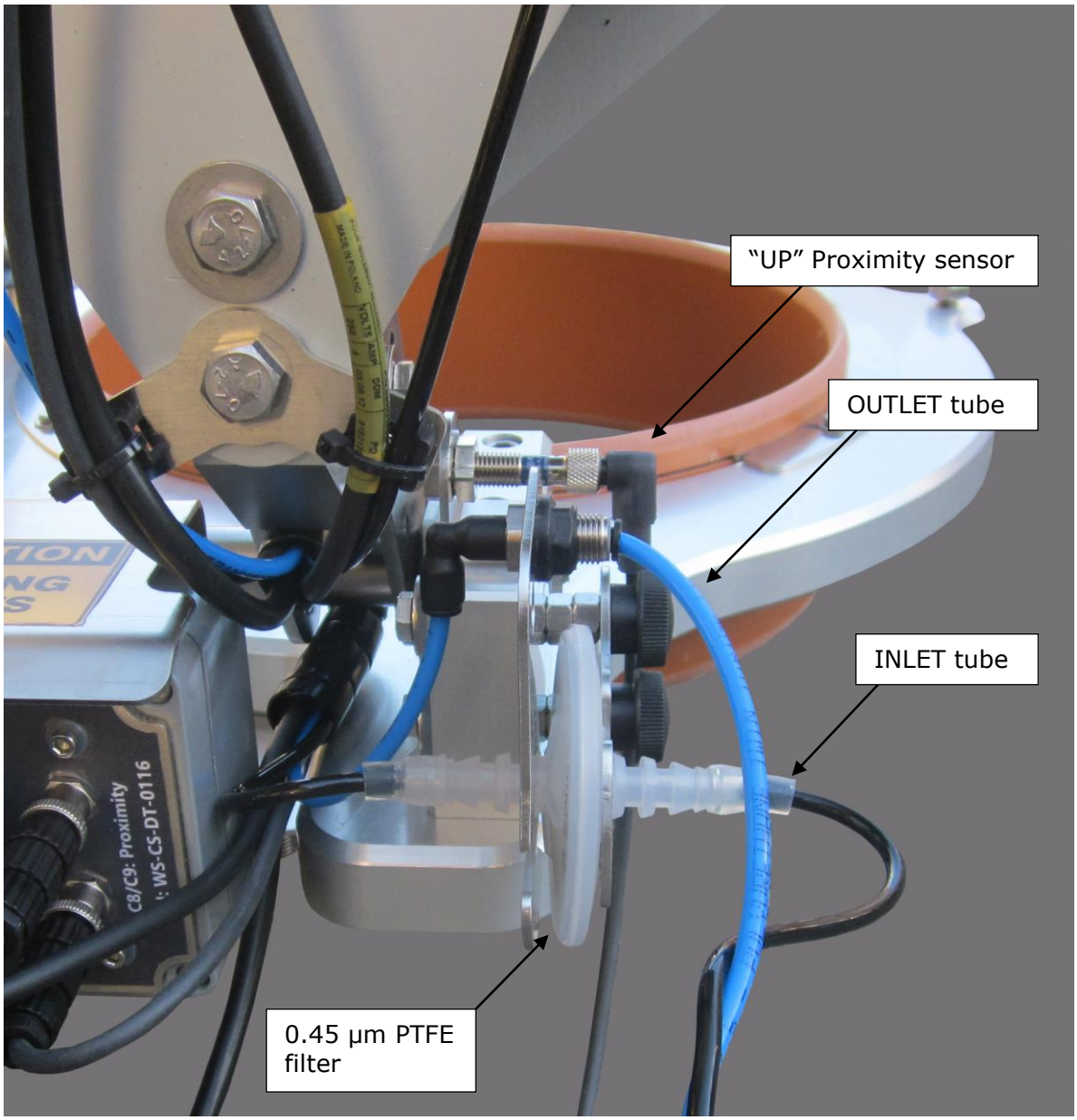
- Connect the RS485 plug to the relative port (1 to 16). Push the plug into the socket and tighten the ring. Make sure the plug is fully inserted.
- Connect the blue tube to the OUTLET (upper joint), as indicated by the label *Blue*.
- Connect the black (or white) tube to the INLET (lower joint), as indicated by the label *White/Black*.

As previously indicated for the chamber connection, for both INLET and OUTLET joints, the tube is secured by a ring nut.

a) Make sure the ring nut is installed on the tube before inserting it.
b) Push the tube completely into the metal fitting.
c) Finally, tighten the ring nut.

3) Unroll the cable and connect the "AC SIDE" of the cable.

- Connect the RS485 plug to the connector C7 of the chamber panel. Push the plug into the socket and tighten the ring. Make sure the plug is fully inserted.
- Connect the blue tube to quick coupling joint, as shown in the picture. Push the tube to connect. If you need to release it, press the black ring and pull the tube.
- Connect the black (or white) tube on the right side of the PTFE filter. A piece of silicone tube ensured the seal of the joint. Symmetrically, the chamber INLET tube is already connected to the left side of the PTFE filter.



4) Check that the fan, linear actuator, proximity sensors and pressure/temperature gauge are properly connected. Check chapter 6 for an accurate description of the chamber panel.

5) Make sure the emergency button is released. Rotate it clockwise to check.

Repeat the operation for each chamber.

4.4 Connection test

Once the installation is completed, execute the following steps to verify the status of the connections:

1) Open the flux station case and switch on the system by pulling the switch and moving it into the ON position. The display of the station will turn on, displaying the West Systems logo and showing the menu after a couple of seconds. If the display is still off, check again the installation of the power supply system.
2) Enter the menu *2. Commands*, then *2.13 Select active chamber*. For a more accurate description of the display functions please refer to chapter 7. Select "Chamber 1" and press OK. You should hear the two electro-valves switching.
3) Open the multiplexer case. Each electro-valve has a LED which show the status. When the LED is OFF, the valve is closed. When the LED is ON, the valve is open. You should see the first LED of the INLET group ON and the first LED of the OUTLET group ON. If that does not happen, please check the RS485 connection between the station and the multiplexer.
4) Back to the station display: access the menu *2. Commands*, then *2.1 Manage chamber*. If the chamber is closed, on the display the proximity sensors "DW" must be checked.

   ☐ UP

   ■ DN

   If not, check the chamber connections.
   Also, check if the sensor is in the correct position, about 1 mm far from the bolt. If necessary, move the bolt closer or farther from the sensor.
5) Press the UP key to open the chamber. If the chamber is not moving, control the linear actuator cable and that the emergency stop button is released. Once the chamber is opened, check the display: the proximity sensors "UP" must be checked.

   ■ UP

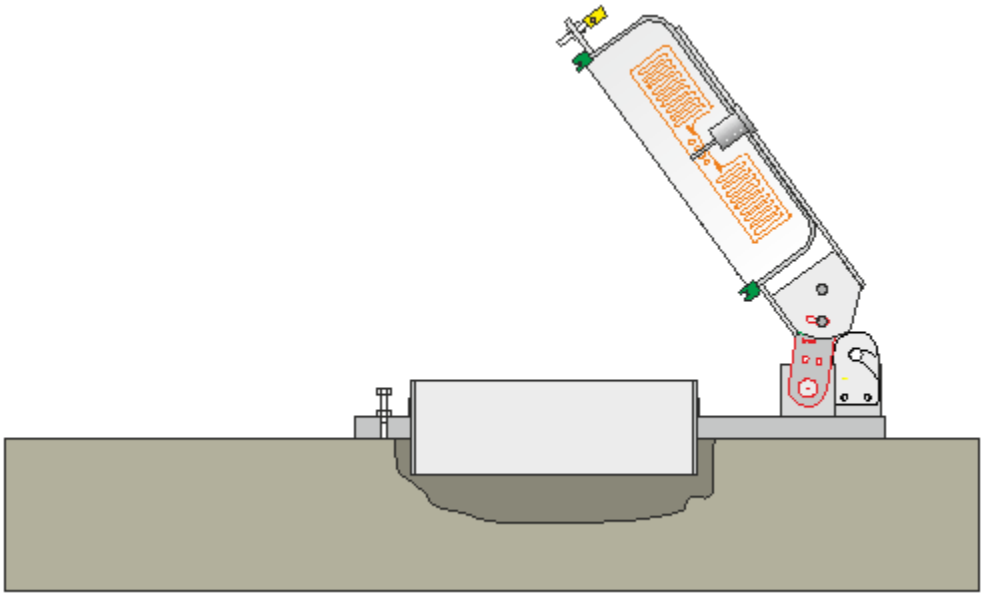
   ☐ DN

6) Leave the chamber open for finalizing the positioning of the chamber to the soil.

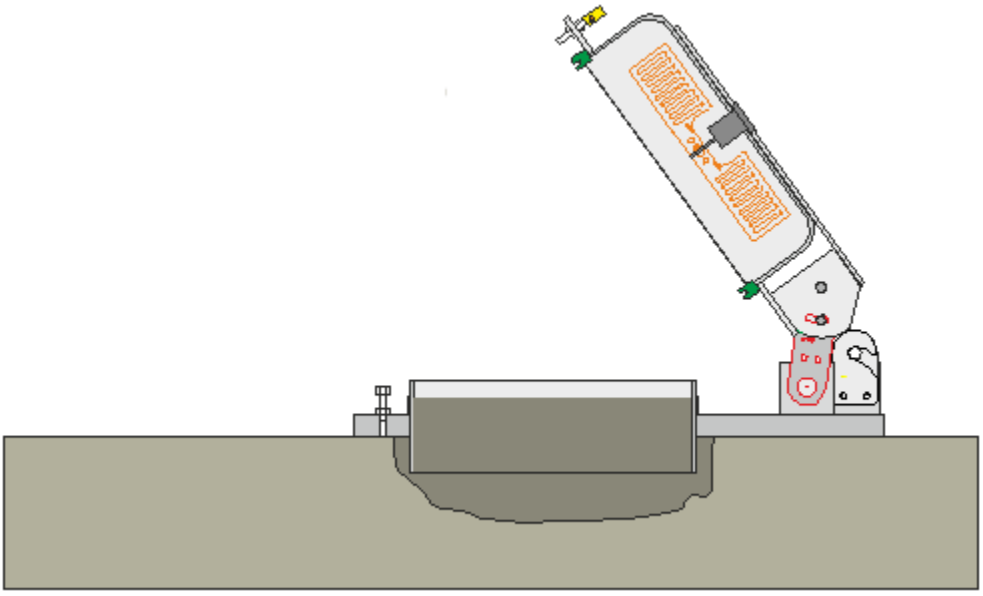
Repeat the steps 2-6 for each chamber.

4.5 Positioning of the chambers

Dig a hole of 35 cm diameter and 10 cm depth.
Place the chamber to the ground letting the collar enter the soft soil.



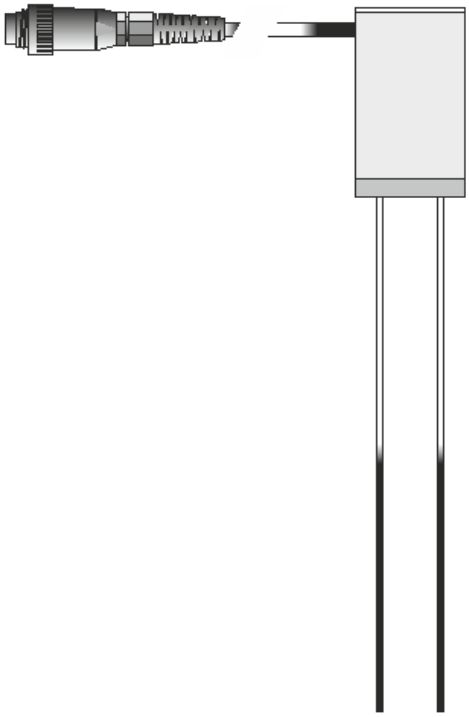
The accumulation chamber base must be at the same level of the soil surface. Fill the collar with soil leaving the minimum empty space, to avoid carbon dioxide accumulation inside the collar.



4.6 Soil sensors

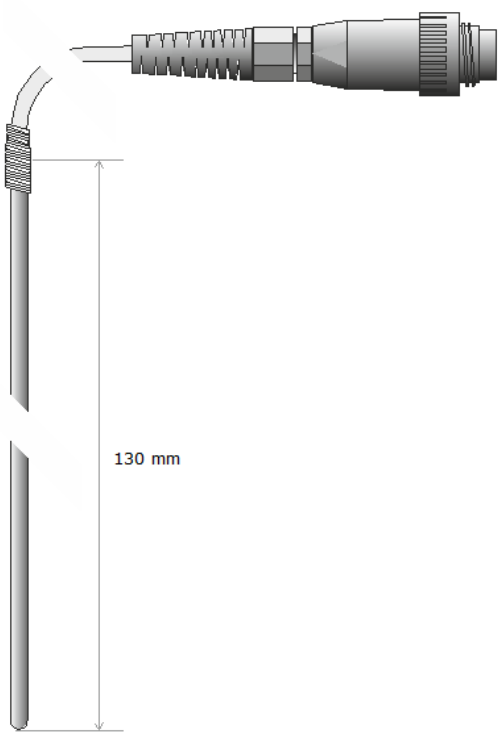
A platinum 100 Ohm temperature probe and a Campbell Scientific CS616 Time Domain Reflectometer can be connected to the chamber box in order to measure the soil temperature and the soil water content.

Soil water content probe



Plug the probe to the C6 connector of the chamber box. Make sure the plug is fully inserted and tighten the ring.
Make sure the cable does not interfere with the chamber movement. From the station menu, close the chamber to verify all the cables are in a secure position. Open the chamber again at the end of test.
Insert the probe into the soil. The probe rods can be inserted vertically into the soil surface or buried at any orientation to the surface. A probe inserted vertically into a soil surface will give an indication of the water content in the upper 30 cm of soil. The probe can be installed horizontal to the surface to detect the passing of wetting fronts or other vertical water fluxes. A probe installed at an angle of 30 degrees with the surface will give an indication of the water content of the upper 15 cm of soil.
The method used for probe installation can affect the accuracy of the measurement. **The probe rods should be kept as close to parallel as possible** when installed to maintain the design wave guide geometry. The sensitivity of this measurement is greater in the regions closest to the rod surface than at distances away from the surface. Probes inserted in a manner which generates air voids around the rods will reduce the measurement accuracy. In most soils, the soil structure will recover from the disturbance during probe insertion.

Soil temperature probe



Plug the probe to the C5 connector of the chamber box. The connector is a quick release and doesn't need to be screwed. Insert the probe into the soil at the desired depth.
Make sure the cable does not interfere with the chamber movement. From the station menu, close the chamber to verify all the cables are in a secure position. Open the chamber again at the end of test.

5. Sensors

The station is able to acquire 8 analog channels and up to 32 digital (RS485 channels).

The RS485 sensors are those connected to the internal (e.g. TLD Methane detector) or external RS485 bus (chamber, soil moisture and humidity sensors). While the station is able to acquire automatically the digital sensors configuration (using "Scan RS485" function, command 2.9.2), the analog channels need to be configured.

Note: the flux station is shipped from fabric already configured and ready to start the monitoring.

There are two ways of configuring the channels:

- Directly on the display of the station (command 3.1.1), see chapter 6 for detailed instructions.
- Editing the channels on the database (table *phisicalchannels*) and then uploading to the station from WS-Scada (command Set Channels' Configuration); see chapter 12 for detailed instructions.

The following table shows the default configuration.

Channel	Name	FullScale	LowScale	PlotCurve	Conf	Input	Note
0	CO2	20000	0	-1	FF06	4-20 mA	Connected to LI-COR LI-820 Carbon Dioxide output
1	Ch.1	5000	0	0	FF05	0-5 V	Available for AUX sensors.
2	Ch.2	5000	0	0	FF06	4-20 mA	Available for AUX sensors.
3	CellT	100	0	0	FF05	0-5 V	Connected to LI-COR LI-820 Cell Temperature output
4	Ch.4	5000	0	0	FF05	0-5 V	Available for AUX sensors.
5	Ch.5	5000	0	0	FF05	0-5 V	Available for AUX sensors.
6	Ch.6	1100	800	0	FF05	0-5 V	Available for AUX sensors.
7	P.Flow	1000	0	0	FF0F	0-5 V	Connected to flow meter

5.1 Carbon dioxide detector

Specifications

Manufacturer:	LI-COR
Model:	LI-820
Working principles:	Single-Beam Dual-Wavelength NDIR
Measurement range:	from 0 to 20000 ppm
Accuracy:	< 3% of reading
RMS Noise at 370 ppm with 1 sec signal filtering:	< 1 ppm
Operating temperature:	-20 to 45°C
Relative Humidity Range:	0 to 95%, Non-Condensing

Connections
The LI-820 is equipped with a RS232 serial port and a 14-pin terminal strip. The following table describes the pinout.

LI-820 Terminal Pin	Signal
1	Voltage In, 12-30 VDC
2	Ground
3	High Alarm
4	Ground
5	Low Alarm
6	Ground
7	Voltage output channel 2
8	Ground
9	Voltage output channel 1
10	Ground
11	Current output channel 2
12	Ground
13	Current output channel 1
14	Ground

The LI-820 is connected to the station by two cables:
- CH0 cable (Black cap), which provides power supply and CO2 signal
- CH3 cable (Red cap), which provides Cell temperature signal

The pinout of the each cable is described below.

CH0 cable Pinout

CH0 Cable Pin	Signal	Wire color	Connected to LI-820 pin
1	N.C.		
2	Signal +	Green	11
3	N.C.		
4	N.C.		
5	GND	Blue	2
6	N.C.		
7	Signal GND	Yellow	12
8	N.C.		
9	+12VDC	Red	1

CH3 cable Pinout

CH3 Cable Pin	Signal	Wire color	Connected to LI-820 pin
1	N.C.		
2	Signal +	Red	9
3	N.C.		
4	N.C.		
5	N.C.		
6	N.C.		
7	Signal GND	Blue	10
8	N.C.		

9	N.C.		

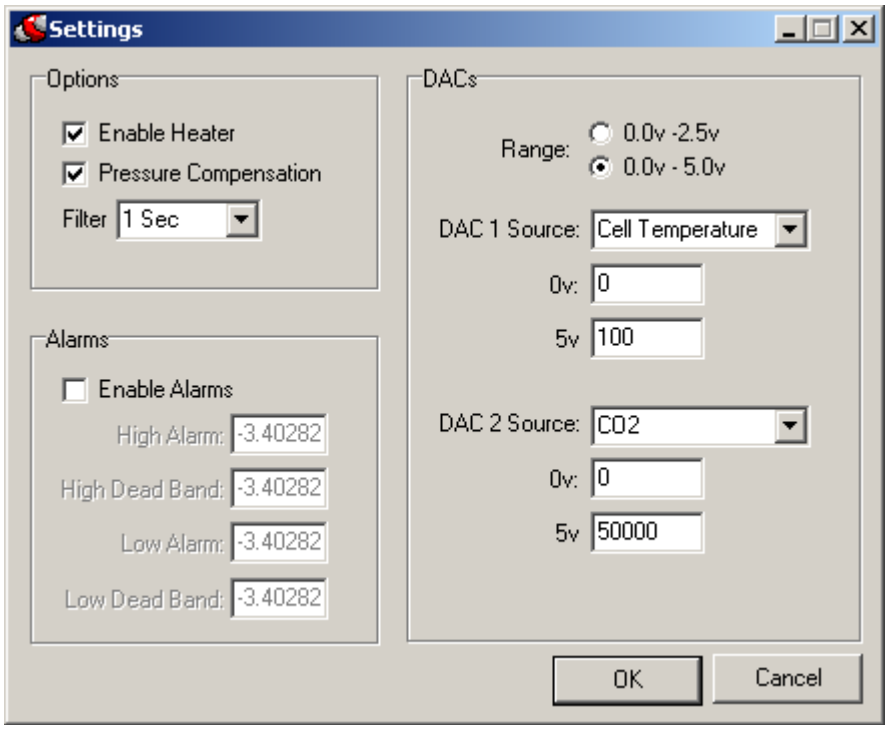
Configuration

In order to configure or calibrate the LI-820 detector, you'll need to connect with a laptop to the LI-820 RS232 serial port, and start the LI-820 PC Software (see the LI-820 manual for detailed instructions).

The sensor comes from West Systems fabric configured as following:

Parameter	**Setting**
Heater	Enabled
Pressure Compensation	Enabled
Filter	1 second
DAC1 Source	Cell temperature
DAC1 Range	0-100 °C
DAC1 Source	CO2
DAC1 Range	0-20000

The following screenshot of the LI-COR PC software shows the configuration.



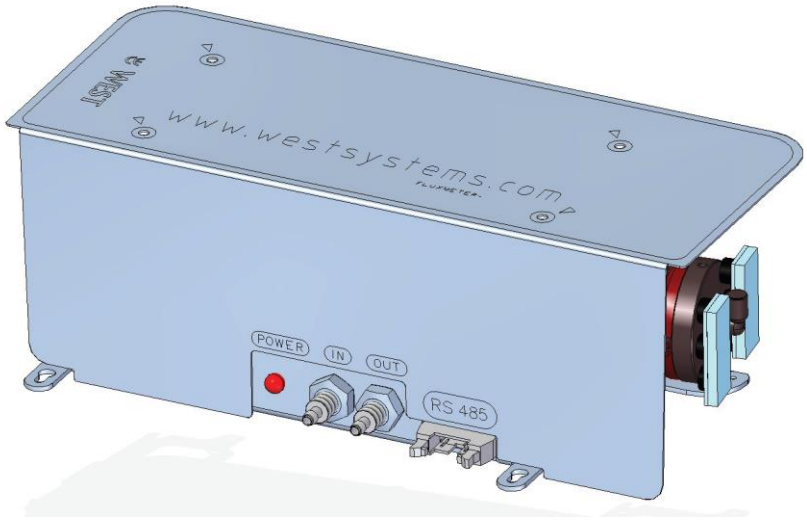
5.2 Methane detector

Specifications

Manufacturer:	West Systems
Model:	WS-CH4-TLD
Working principles:	TDLAS
Measurement range:	from 0 to 10%vol *
Resolution:	0.1 ppm
Accuracy:	± 10% of reading
Operating temperature:	-10 to 45°C
Relative Humidity Range:	0 to 95%, Non-Condensing
Selectivity to methane	

* The detector is actually able to measure concentration up to 100% vol, which is not purpose of soil emission measurement.

The detector is based on a TLD (tunable laser diode) coupled with a multipass cell. The Tunable Diode Laser Absorption Spectroscopy detection method is based on the principle of absorption of the light by a medium which is described by the Beer Lambert law.
The operational wavelength of the laser diode is 1650nm. The signal is then optimized by adding a multipass optical cell, which allows increasing the pathlength in the gas.



The IN and OUT gas fittings can be used with Rilsan 6x4 mm tubes or silicon 5x3.2 tubes. Please respect inlet and outlet ports.

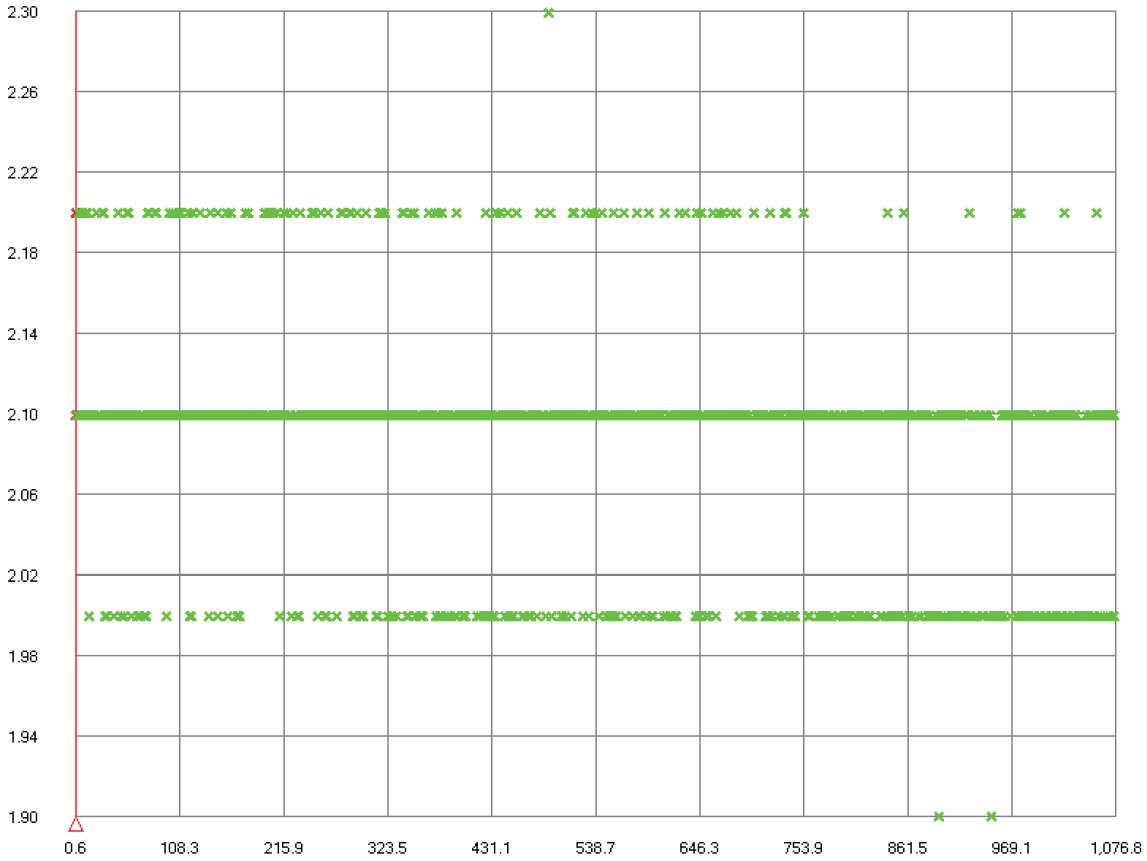
Always make sure that a filter (porosity 0.20 m or less) is applied between the inlet on the instrument and the inlet of WSCH4-TLD detector. If water, dust, dirt or any other polluting substance comes inside the cell, it will alter the behaviour of the mirrors. In the best case, it will be necessary to send the instrument to West Systems for a cleaning, which is a long and expensive procedure. Never open the protective case of the WS-CH4-TLD. Some components such as the optical fiber could be damaged if touched or bent.

The WS-CH4-TLD has a serial output hence it is connected to the flux station RS485 bus. The RS485 cable provides both power supply and communication.

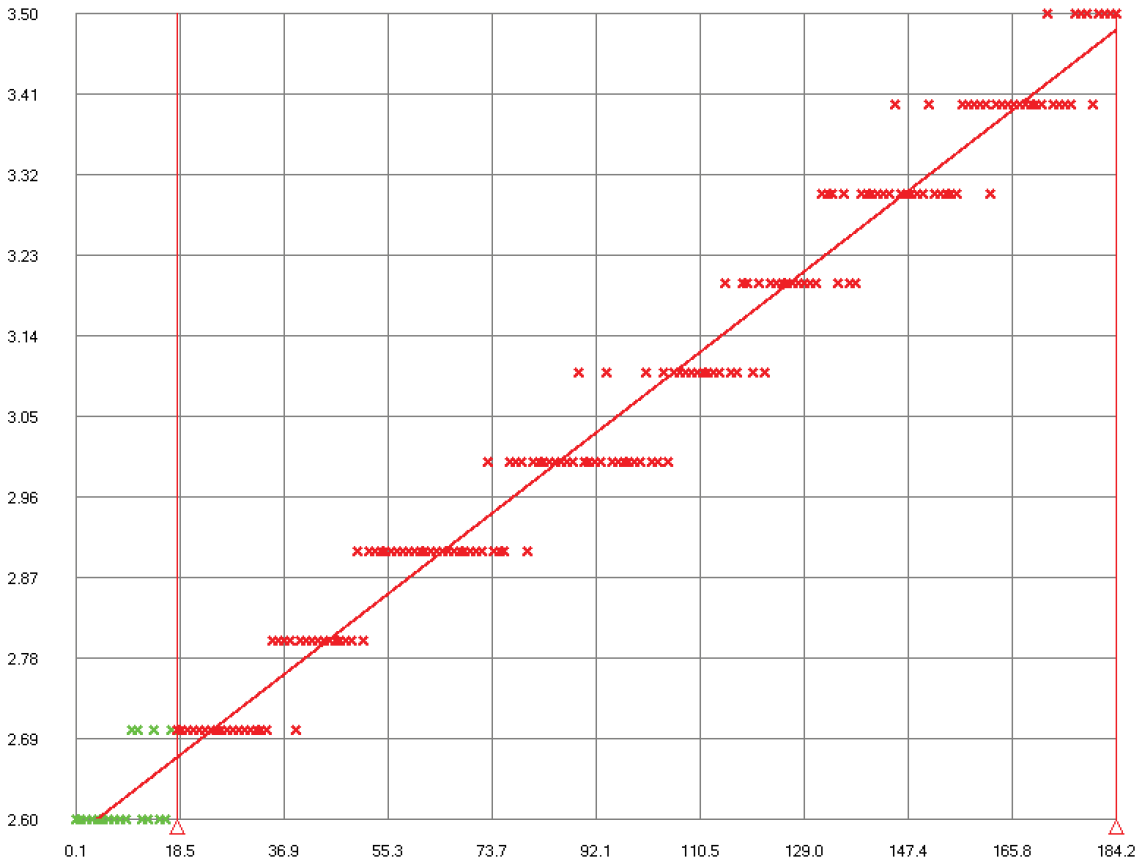
RS485 Cable Pin	**Signal**
1	GND
2	GND
3	+12VDC
4	+12VDC
5	GND
6	GND
7	RS485 B
8	RS485 B
9	RS485 A
10	RS485 A

The following plot (ppm vs. seconds) shows a stability test while injecting atmospheric air for about 1,000 seconds.

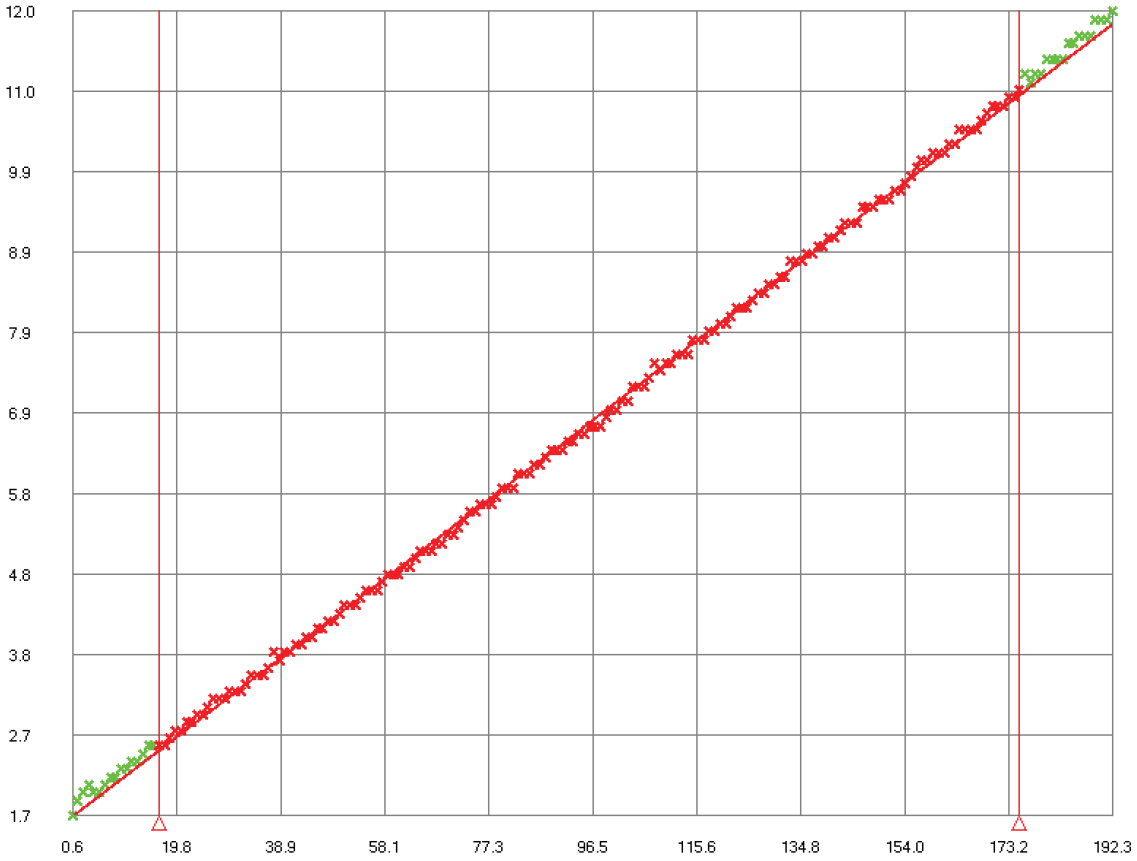
5 Sensors



The plot (ppm vs. seconds) shows an accumulation curve while measuring a flux of 1.7 mmoles/m^2 per day



The plot (ppm vs. seconds) shows an accumulation curve while measuring a flux of 18 mmoles/m^2 per day

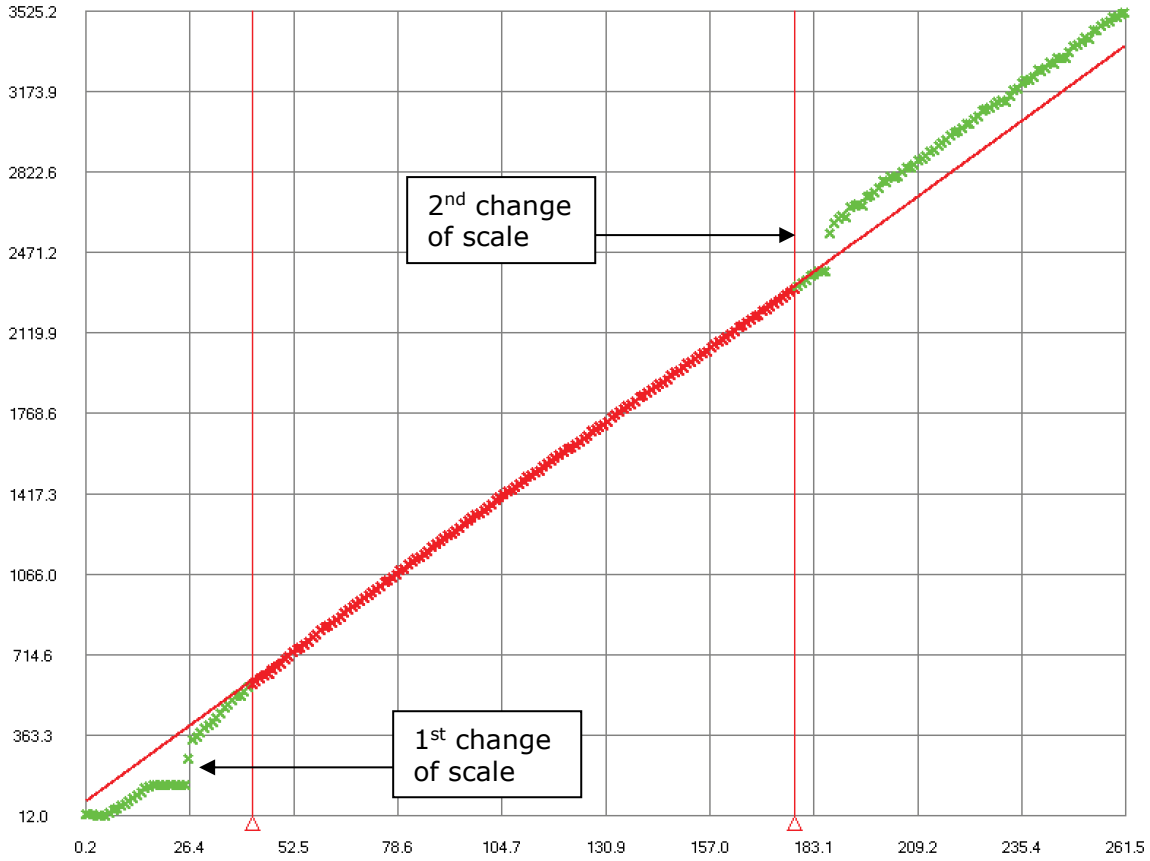


In order to guarantee the measuring of CH4 concentration in a wide range (0-100% vol), the sensor needs to apply different settings on the laser diode. This adaptations produce a gap of a few seconds during which a valid concentration value is not available.

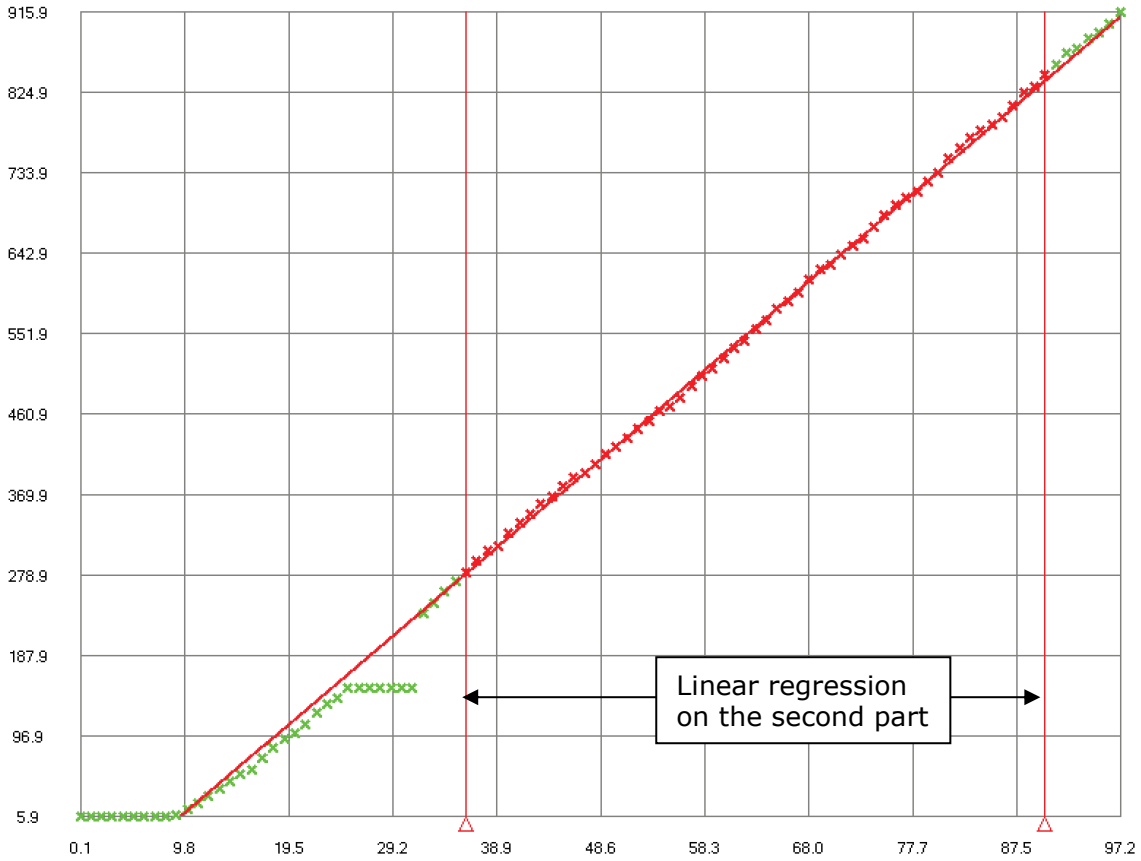
Computing flux

The sensor presents a first change of scale around 140-150 ppm and a second change around 2300-2400 ppm. During a change of scale, the value remains constant for about 10 seconds.

5 Sensors

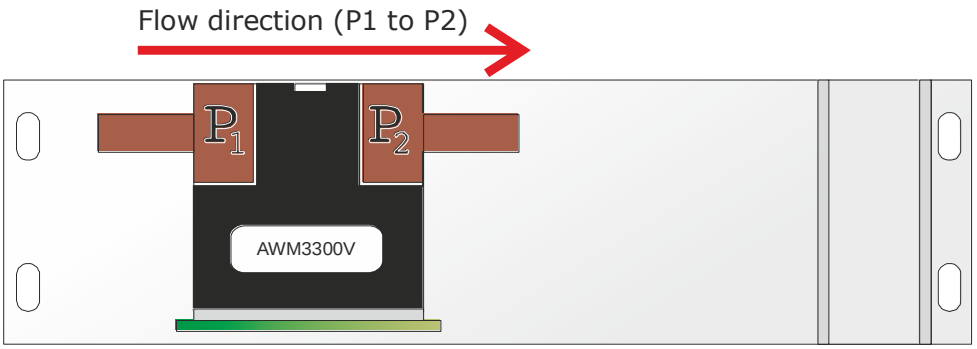


If you cross that threshold during the accumulation curve, please apply the interpolation on the second part of the curve. Do not include the ten-seconds gap into the linear regression in order to prevent measure errors. Extend the duration of the accumulation curve if necessary.



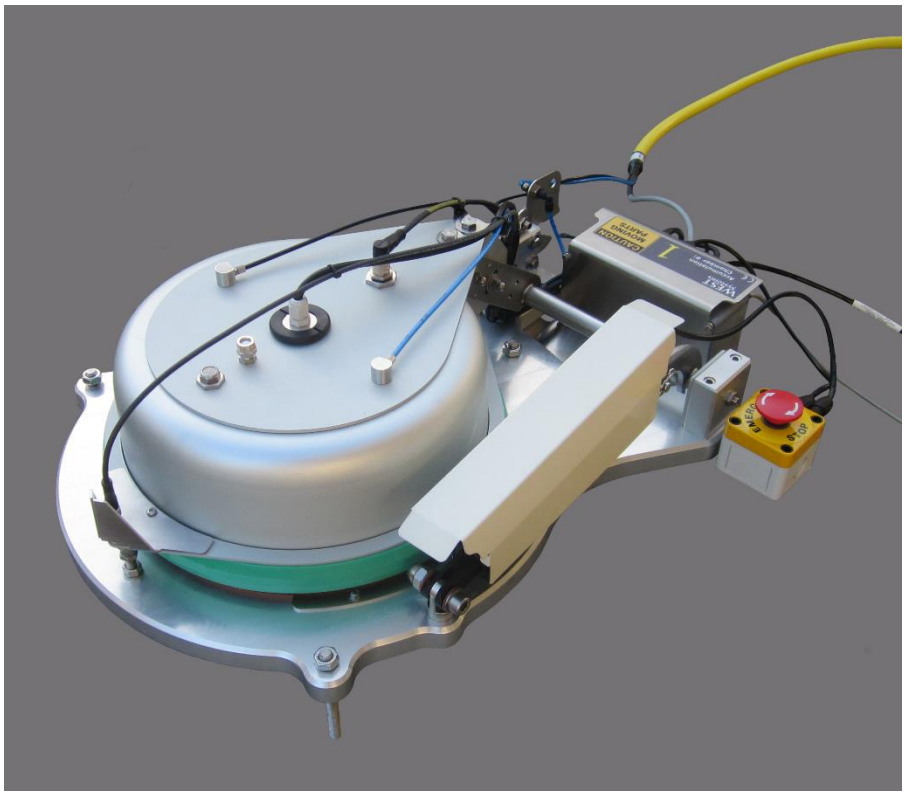
5.3 Gas line flow meter

Manufacturer: WEST Systems
(Sensor made by Honeywell-SensorTechnics)
Ordering code: AWM3300
Gas flow
Range: 0 to 1500 SCCM
Accuracy: 2% of F.S.
Power supply: 10 Volt Typical 30 mA @ 24 Volt



The Pumping Flow channel measures the gas flow in the sampling line.
The value must be in the range 700-1400 SCCM. A value less than that means there is some kind of obstruction or the filters are dirty.
A value close or less than zero means that the pump is not working.

6. The accumulation chamber



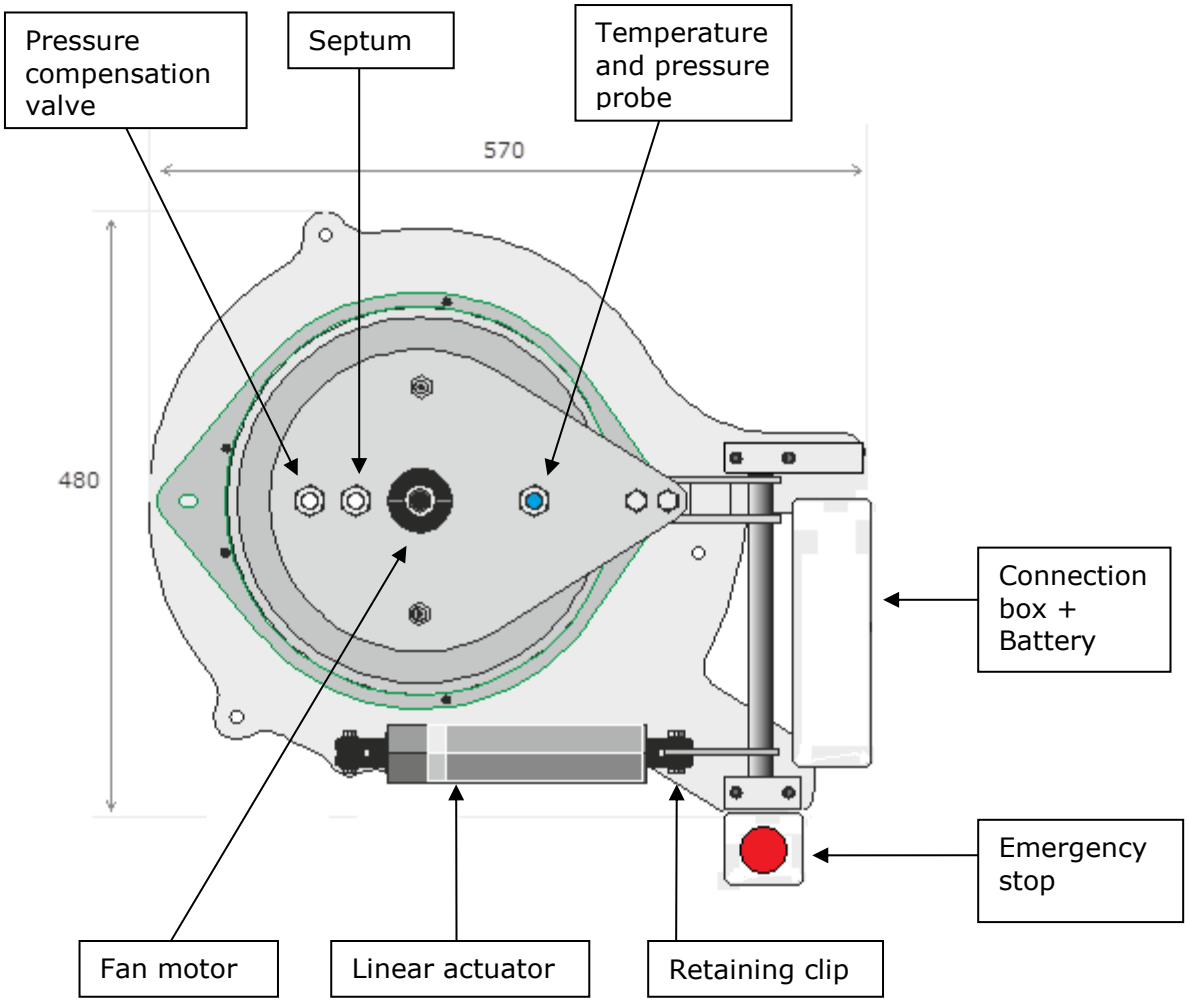
6.1 Components

Linear actuator
The linear actuator moves the chamber from the open position (idle) to the closed position (sampling) and vice versa.
The actuator is protected again rain and direct solar radiation by a white aluminium shield. The shield is snap-fitted over the actuator.
The actuator is equipped with a safety retaining clip (see chapter 1.1), for freeing the motor from the chamber axle in emergency situations.

Manufacturer: Linak
Model: LA12
Maximum thrust: 750 N

Emergency stop
The linear actuator is equipped with an emergency stop button which allows to immediately stop the movement of the chamber, in case persons or goods are in the way of the chamber movement and risk of being pressed.
Once pressed, the operation of the linear actuator is inhibited until it is manually restored. Twist the button clockwise to re-enable the operation.

6 The accumulation chamber



Pressure compensation valve
The valve is used to maintain pressure equilibrium between inside the chamber and the surrounding air outside the chamber, avoiding the pressurization of the chamber that would alter the gas flow from soil.

Pressure and temperature sensor
Each chamber is equipped with a digital barometric pressure and air temperature sensor. The parameters are acquired inside the chamber during the measure.

Manufacturer: Freescale
Ordering code: MPL3115A2
Pressure range: 500 to 1100 mBar
Temperature range: -40 to 85 °C

Septum
The septum is used for trace gas sampling. It allows collecting subsamples directly from the chamber gas content. The flux of trace gas species can be manually computed by analysing the subsample.

Manufacturer: Supelco
Ordering code: 27356
Material: PTFE/Silicone
Diameter: 11 mm

Battery
Internal buffer battery, enclosed in the connection box. The battery provides additional local current to the chamber. It is automatically recharged by the flux station.

Manufacturer: Yuasa
Ordering code: NP0.8-12
Type: Lead acid
Voltage: 12 V
Capacity: 0.8Ah at 20hr rate to 1.75VPC

Fan
The chamber internal fan ensures the homogenization of the gas mixture inside the chamber during the flux measurement.

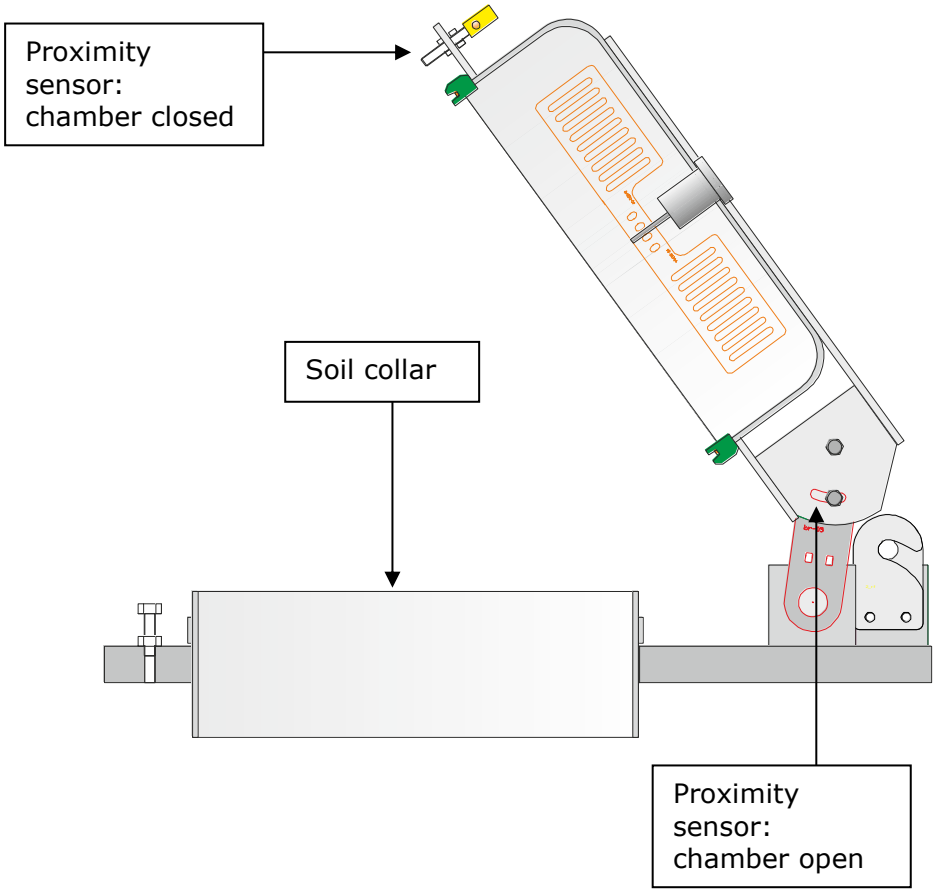
Manufacturer: McLennan
Model: 1271-12-21
Output speed: 80 rpm
Maximum output torque: 2.5 Ncm

Soil temperature probe
Manufacturer: Jumo
Type: Pt100 DIN IEC 751 Class B 4 wires
Range: 0 to 200 °C
Accuracy 0.3°C
Probe length 130 mm
Probe diameter 6 mm
Cable length 3 m
Cable PTFE and silicone with protective anti-bend spring.

Soil water content probe
Manufacturer: Campbell Scientific
Ordering code: CS616
Water content Range 5-50 %
Water content Accuracy 3%

The CS616 Water Content Reflectometer measures the volumetric water content of porous media using time-domain measurement methods.
The Water Content Reflectometer consists of two stainless steel rods connected to a printed circuit board. A shielded four-conductor cable is connected to the circuit board to supply power, enable the probe, and monitor the pulse output. The circuit board is encapsulated in epoxy. The probe rods can be inserted from the surface or the probe can be buried at any orientation to the surface.
The CS616 response is dependent on the dielectric constant of the material surrounding the probe rods. Water is the principal contributor to the dielectric constant value, but the solid constituents such as quartz, clay and organic matter also affect the measurement. The same calibration of volumetric water content to probe output signal period may not apply to all soils. Accuracy can be optimized by using calibrations derived for a specific soil. Accuracy of ± 2.0% over the entire water content range and for a wide range of soil types is routinely obtained in our laboratory. Applying the general calibrations from the operating manual provides accuracy of ± 3.0%.

Proximity sensors
Two proximity sensors are installed, one at the base of the chamber and one at the axle. The sensors control the full opening and full closing of the accumulation chamber. The information is stored as meta-data of the analysis file and therefore is stored in the database when it is download by WS-Scada. The information can be consulted anytime to cross-check the flux measurement validation.
Type: inductive proximity
Manufacturer: Wenglor
Model: IM020BM60TB8
Range: 2mm-Shielded
Protection grade: IP67
Thread: M8



6.2 Connections

The paragraph will explain the connection panel of the accumulation chamber. Please note that it is not possible to connect a device to the wrong connector since each socket is univocal. In case two connectors are of the same type (example: C8/C9 and C3/C4 sensors), it means that each plug can be connected to either one of the sockets.

Chamber connection panel

Connector C1: Expansion
The connector C1 can used to connect auxiliary sensors. The chamber allows the connection of up to two analog sensors, sampled by two 24-bit Analog to Digital Converters. Moreover, it is possible to acquire a sensor equipped with a RS232 serial port. Please note that in this case it is necessary to load on the chamber board a customized firmware which implements the sensors serial protocol.

C1 Connector Pinout	
Pin	**Signal**
1	Analog input 1 (+)
2	Analog input 1 (-)
3	Sensor power supply
4	RS232 TX
5	RS232 RX
6	Analog input 2 (+)
7	Analog input 2 (-)

Connector C2: Pressure and temperature gauge
The connector C2 is used to connect the pressure and temperature gauge built-in inside the chamber. The gauge is connected through a I^2C serial bus.

C2 Connector Pinout	
Pin	**Signal**
1	I^2C SDA
2	GND
3	I^2C SCL
4	POWER SUPPLY

Connectors C3/C4: Fan and linear actuator
The connectors C3 and C4 are used to connect the fan motor and the linear actuator which opens and closes the chamber.

The emergency stop button is inserted between the linear actuator and the C3/C4 connector. Please note that the fan and the actuator can be connected to either one of the sockets.

C3/C4 Connector Pinout	
Pin	**Signal**
1	GND
2	PUMP
3	CHAMBER UP
4	CHAMBER DOWN
5	FAN

Connector C5: Soil temperature probe
The connector C5 is used to connect the 4-wire PT100 soil temperature probe.

C5 Connector Pinout	
Pin	**Signal**
1	PT100-RED (1)
2	PT100-RED (2)
3	PT100-WHITE (1)
4	PT100-WHITE (2)
5	GND

Connector C6: Soil water content probe
The connector C6 is used to connect the TDR soil water content sensor. The sensor output is a voltage square wave with frequency dependent on water content.

C6 Connector Pinout	
Pin	**Signal**
1	POWER SUPPLY
2	IGNITION
3	FREQUENCY
4	GND
5	NC
6	NC
7	NC

Connector C7: RS485
The connector C7 is used to connect the chamber to the flux station or to the multiplexer unit, in case of a multi-chamber system. The connector provides both power supply to the chamber and communication with the station control unit. The flux station provides two power supply voltages. The "+12V NOT SWICTHED" is always ON if the station is ON. It is used for recharging the chamber internal battery. The "+12V SWITCHED" is activated by the multiplexer only when the chamber needs to be sampled.

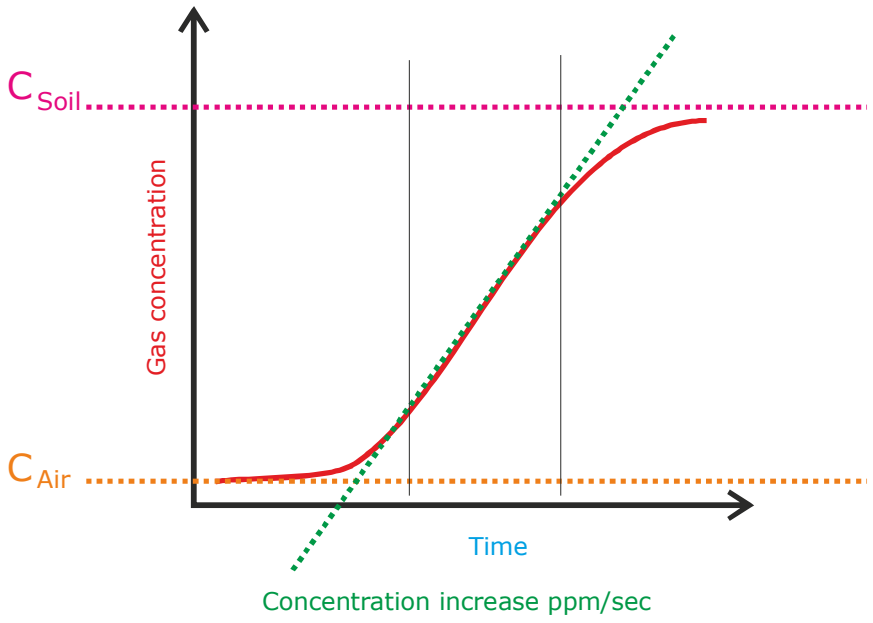
C7 Connector Pinout	
Pin	**Signal**
1	GND
2	RS485 A
3	RS485 B
4	GND
5	+12V NOT SWITCHED
6	+12V SWITCHED
7	NC

Connectors C8/C9: Proximity sensors
The connectors C8 and C9 are used to connect the proximity sensors which gives indication of whether the chamber could successfully open or close.

C8/C9 Connector Pinout	
Pin	**Signal**
1	POWER SUPPLY
2	PROX.SENSOR 1 SIGNAL
3	GND
4	PROX.SENSOR 2 SIGNAL

6.3 Measuring soil flux

The flux is proportional to the concentration increase ratio ppm/sec. The proportionality factor depends on the chamber volume/surface ratio as well as the barometric pressure and the air temperature inside the accumulation chamber.



The station, in the default configuration record and store the barometric pressure, the air temperature and the soil temperature.

The variation of few degrees of temperature do not affect the evaluation of flux very much, then it's possible to use the air temperature instead of the temperature of the gas mixture into the accumulation chamber.

Choosing the flux measurement unit
The first measurements made, 20 years ago, with the accumulation chamber was expressed in cm/sec which is a speed, the speed of carbon dioxide flowing out from the soil. During the last decades, several units have been used by volcanologist and by geochemistry researchers. The most common unit is [grams/m^2 per day], but using the same instrument for two gas species to express the flux using this unit means to have two different conversion factors. West Systems uses the unit [moles/m^2 per day] that has two advantages: A single conversion factor for every gas specie and an easy conversion of the flux in [grams/m^2 per day] simply multiplying the result expressed in [moles/m^2 per day] times the molecular weight of the target gas.

The WS-Scada software expresses the flux using the unit [moles/m^2/day]

The accumulation chamber factors
Here following the formula used to compute the A.c.K.:

$$K = \frac{86400 \cdot P}{10^6 \cdot R \cdot T_k} \cdot \frac{V}{A}$$

Where

- **P** is the barometric pressure expressed in mBar (HPa)
- **R** is the gas constant 0.08314510 bar L K-1 mol-1
- **Tk** is the air temperature expressed in Kelvin degree
- **V** is the chamber net volume in cubic meters
- **A** is the chamber inlet net area in square meters.

The dimensions of the A.c.K. are

$$K = \frac{moles \cdot meter^{-2} \cdot day^{-1}}{ppm \cdot sec^{-1}}$$

An example:
If the slope of the flux curve is 2.5 ppm/sec, the barometric pressure is 1011 mBar (HPa) and the air temperature is 23 °C.
From the table (Page 5.7) get the value that correspond to the barometric pressure and temperature. In this case I get the value computed for 25°C and 1013 mBar : 0.440
Then the flux is: 2.5 x 0.440 = 1.10 moles per square meter per day.

WS-Scada
WS-Scada automatically computes the ACK value every time it receives data from the station.

6 The accumulation chamber

The chamber area and volume are stored in the database.
The values of pressure and temperature are acquired from the sensors.

6 The accumulation chamber

In the following table the factors for the conversion from ppm/sec slope to moles/m^2/day are reported.

Barometric pressure [mBar] \ Air temperature [°C]	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40
1100	0.589	0.578	0.567	0.556	0.546	0.536	0.527	0.517	0.509	0.500	0.492	0.484	0.476
1080	0.578	0.567	0.556	0.546	0.536	0.526	0.517	0.508	0.499	0.491	0.483	0.475	0.467
1060	0.567	0.557	0.546	0.536	0.526	0.516	0.507	0.499	0.490	0.482	0.474	0.466	0.459
1040	0.557	0.546	0.536	0.526	0.516	0.507	0.498	0.489	0.481	0.473	0.465	0.457	0.450
1020	0.546	0.536	0.525	0.516	0.506	0.497	0.488	0.480	0.472	0.464	0.456	0.449	0.441
1000	0.535	0.525	0.515	0.505	0.496	0.487	0.479	0.470	0.462	0.455	0.447	0.440	0.433
980	0.525	0.515	0.505	0.495	0.486	0.478	0.469	0.461	0.453	0.445	0.438	0.431	0.424
960	0.514	0.504	0.494	0.485	0.476	0.468	0.460	0.452	0.444	0.436	0.429	0.422	0.415
940	0.503	0.494	0.484	0.475	0.466	0.458	0.450	0.442	0.435	0.427	0.420	0.413	0.407
920	0.493	0.483	0.474	0.465	0.456	0.448	0.440	0.433	0.425	0.418	0.411	0.405	0.398
900	0.482	0.473	0.464	0.455	0.447	0.439	0.431	0.423	0.416	0.409	0.402	0.396	0.390
880	0.471	0.462	0.453	0.445	0.437	0.429	0.421	0.414	0.407	0.400	0.393	0.387	0.381
860	0.460	0.452	0.443	0.435	0.427	0.419	0.412	0.404	0.398	0.391	0.384	0.378	0.372
840	0.450	0.441	0.433	0.425	0.417	0.409	0.402	0.395	0.388	0.382	0.376	0.369	0.364
820	0.439	0.431	0.422	0.414	0.407	0.400	0.392	0.386	0.379	0.373	0.367	0.361	0.355
800	0.428	0.420	0.412	0.404	0.397	0.390	0.383	0.376	0.370	0.364	0.358	0.352	0.346
780	0.418	0.410	0.402	0.394	0.387	0.380	0.373	0.367	0.361	0.355	0.349	0.343	0.338
760	0.407	0.399	0.391	0.384	0.377	0.370	0.364	0.357	0.351	0.345	0.340	0.334	0.329
740	0.396	0.389	0.381	0.374	0.367	0.361	0.354	0.348	0.342	0.336	0.331	0.325	0.320
720	0.385	0.378	0.371	0.364	0.357	0.351	0.345	0.339	0.333	0.327	0.322	0.317	0.312
700	0.375	0.368	0.361	0.354	0.347	0.341	0.335	0.329	0.324	0.318	0.313	0.308	0.303
680	0.364	0.357	0.350	0.344	0.337	0.331	0.325	0.320	0.314	0.309	0.304	0.299	0.294
660	0.353	0.347	0.340	0.334	0.327	0.322	0.316	0.310	0.305	0.300	0.295	0.290	0.286
640	0.343	0.336	0.330	0.323	0.318	0.312	0.306	0.301	0.296	0.291	0.286	0.281	0.277
620	0.332	0.326	0.319	0.313	0.308	0.302	0.297	0.292	0.287	0.282	0.277	0.273	0.268
600	0.321	0.315	0.309	0.303	0.298	0.292	0.287	0.282	0.277	0.273	0.268	0.264	0.260
580	0.311	0.305	0.299	0.293	0.288	0.283	0.278	0.273	0.268	0.264	0.259	0.255	0.251
560	0.300	0.294	0.288	0.283	0.278	0.273	0.268	0.263	0.259	0.255	0.250	0.246	0.242

In the following table the factors for the conversion from ppm/sec slope to CO_2 grams/m2/day are reported.

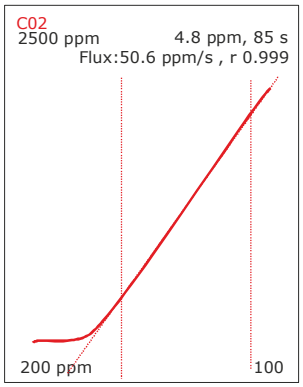
Barometric pressure [mBar] \ Air temperature [°C]	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40
1100	25.918	25.416	24.933	24.468	24.020	23.588	23.172	22.770	22.381	22.006	21.643	21.292	20.952
1080	25.447	24.954	24.480	24.023	23.583	23.159	22.750	22.356	21.974	21.606	21.250	20.905	20.571
1060	24.975	24.492	24.026	23.578	23.147	22.731	22.329	21.942	21.567	21.206	20.856	20.518	20.190
1040	24.504	24.029	23.573	23.133	22.710	22.302	21.908	21.528	21.161	20.806	20.463	20.130	19.809
1020	24.033	23.567	23.120	22.688	22.273	21.873	21.487	21.114	20.754	20.406	20.069	19.743	19.428
1000	23.562	23.105	22.666	22.244	21.836	21.444	21.065	20.700	20.347	20.005	19.675	19.356	19.047
980	23.090	22.643	22.213	21.799	21.400	21.015	20.644	20.286	19.940	19.605	19.282	18.969	18.666
960	22.619	22.181	21.760	21.354	20.963	20.586	20.223	19.872	19.533	19.205	18.888	18.582	18.285
940	22.148	21.719	21.306	20.909	20.526	20.157	19.801	19.458	19.126	18.805	18.495	18.195	17.904
920	21.677	21.257	20.853	20.464	20.090	19.728	19.380	19.044	18.719	18.405	18.101	17.808	17.523
900	21.205	20.795	20.400	20.019	19.653	19.300	18.959	18.630	18.312	18.005	17.708	17.421	17.142
880	20.734	20.333	19.946	19.574	19.216	18.871	18.537	18.216	17.905	17.605	17.314	17.033	16.762
860	20.263	19.871	19.493	19.130	18.779	18.442	18.116	17.802	17.498	17.205	16.921	16.646	16.381
840	19.792	19.408	19.040	18.685	18.343	18.013	17.695	17.388	17.091	16.805	16.527	16.259	16.000
820	19.321	18.946	18.586	18.240	17.906	17.584	17.274	16.974	16.684	16.404	16.134	15.872	15.619
800	18.849	18.484	18.133	17.795	17.469	17.155	16.852	16.560	16.277	16.004	15.740	15.485	15.238
780	18.378	18.022	17.680	17.350	17.032	16.726	16.431	16.146	15.870	15.604	15.347	15.098	14.857
760	17.907	17.560	17.226	16.905	16.596	16.297	16.010	15.732	15.463	15.204	14.953	14.711	14.476
740	17.436	17.098	16.773	16.460	16.159	15.868	15.588	15.318	15.057	14.804	14.560	14.324	14.095
720	16.964	16.636	16.320	16.015	15.722	15.440	15.167	14.904	14.650	14.404	14.166	13.936	13.714
700	16.493	16.174	15.866	15.571	15.286	15.011	14.746	14.490	14.243	14.004	13.773	13.549	13.333
680	16.022	15.712	15.413	15.126	14.849	14.582	14.324	14.076	13.836	13.604	13.379	13.162	12.952
660	15.551	15.249	14.960	14.681	14.412	14.153	13.903	13.662	13.429	13.204	12.986	12.775	12.571
640	15.079	14.787	14.506	14.236	13.975	13.724	13.482	13.248	13.022	12.803	12.592	12.388	12.190
620	14.608	14.325	14.053	13.791	13.539	13.295	13.060	12.834	12.615	12.403	12.199	12.001	11.809
600	14.137	13.863	13.600	13.346	13.102	12.866	12.639	12.420	12.208	12.003	11.805	11.614	11.428
580	13.666	13.401	13.146	12.901	12.665	12.437	12.218	12.006	11.801	11.603	11.412	11.227	11.047
560	13.195	12.939	12.693	12.456	12.228	12.009	11.797	11.592	11.394	11.203	11.018	10.839	10.666

WEST Systems

6 The accumulation chamber

In the following table the factors for the conversion from ppm/sec slope to CH_4 grams/m^2/day are reported.

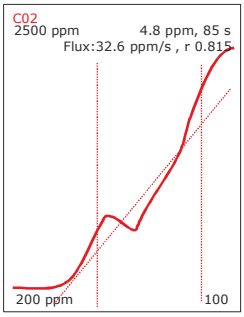
Barometric pressure [mBar]	Air temperature [°C]																			
	-20	-15	-10	-5	0	5	10	15	20	25	30	35	40							
1100	9.446	9.263	9.087	8.918	8.754	8.597	8.445	8.299	8.157	8.020	7.888	7.760	7.636							
1080	9.274	9.095	8.922	8.756	8.595	8.441	8.292	8.148	8.009	7.875	7.745	7.619	7.497							
1060	9.103	8.926	8.757	8.593	8.436	8.284	8.138	7.997	7.861	7.729	7.601	7.478	7.359							
1040	8.931	8.758	8.591	8.431	8.277	8.128	7.985	7.846	7.712	7.583	7.458	7.337	7.220							
1020	8.759	8.589	8.426	8.269	8.118	7.972	7.831	7.695	7.564	7.437	7.314	7.196	7.081							
1000	8.587	8.421	8.261	8.107	7.959	7.816	7.677	7.544	7.416	7.291	7.171	7.055	6.942							
980	8.416	8.253	8.096	7.945	7.799	7.659	7.524	7.393	7.267	7.145	7.028	6.914	6.803							
960	8.244	8.084	7.931	7.783	7.640	7.503	7.370	7.243	7.119	7.000	6.884	6.772	6.664							
940	8.072	7.916	7.765	7.621	7.481	7.347	7.217	7.092	6.971	6.854	6.741	6.631	6.525							
920	7.900	7.747	7.600	7.458	7.322	7.190	7.063	6.941	6.822	6.708	6.597	6.490	6.387							
900	7.729	7.579	7.435	7.296	7.163	7.034	6.910	6.790	6.674	6.562	6.454	6.349	6.248							
880	7.557	7.410	7.270	7.134	7.004	6.878	6.756	6.639	6.526	6.416	6.310	6.208	6.109							
860	7.385	7.242	7.104	6.972	6.844	6.721	6.603	6.488	6.377	6.270	6.167	6.067	5.970							
840	7.213	7.074	6.939	6.810	6.685	6.565	6.449	6.337	6.229	6.125	6.024	5.926	5.831							
820	7.042	6.905	6.774	6.648	6.526	6.409	6.296	6.186	6.081	5.979	5.880	5.785	5.692							
800	6.870	6.737	6.609	6.486	6.367	6.252	6.142	6.035	5.932	5.833	5.737	5.644	5.554							
780	6.698	6.568	6.444	6.323	6.208	6.096	5.988	5.885	5.784	5.687	5.593	5.503	5.415							
760	6.526	6.400	6.278	6.161	6.049	5.940	5.835	5.734	5.636	5.541	5.450	5.362	5.276							
740	6.355	6.232	6.113	5.999	5.889	5.783	5.681	5.583	5.488	5.396	5.307	5.220	5.137							
720	6.183	6.063	5.948	5.837	5.730	5.627	5.528	5.432	5.339	5.250	5.163	5.079	4.998							
700	6.011	5.895	5.783	5.675	5.571	5.471	5.374	5.281	5.191	5.104	5.020	4.938	4.859							
680	5.839	5.726	5.617	5.513	5.412	5.315	5.221	5.130	5.043	4.958	4.876	4.797	4.721							
660	5.668	5.558	5.452	5.351	5.253	5.158	5.067	4.979	4.894	4.812	4.733	4.656	4.582							
640	5.496	5.389	5.287	5.188	5.093	5.002	4.914	4.828	4.746	4.666	4.589	4.515	4.443							
620	5.324	5.221	5.122	5.026	4.934	4.846	4.760	4.677	4.598	4.521	4.446	4.374	4.304							
600	5.152	5.053	4.957	4.864	4.775	4.689	4.606	4.527	4.449	4.375	4.303	4.233	4.165							
580	4.981	4.884	4.791	4.702	4.616	4.533	4.453	4.376	4.301	4.229	4.159	4.092	4.026							
560	4.809	4.716	4.626	4.540	4.457	4.377	4.299	4.225	4.153	4.083	4.016	3.951	3.888							



The "perfect" curve

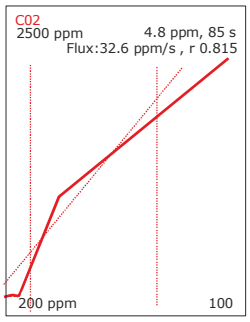
In the figure on the left the plot of a flux measurement.
The shape of the curve is quite perfect and the computation of the flux is done with a very good accuracy: r (regression quality factor) very close to 1.

The following figures show some examples of flux curve shapes**:**



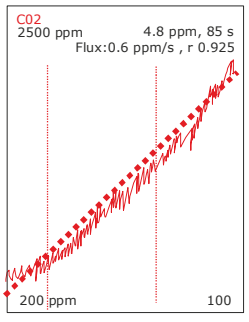
Air contamination

The flux curve is no longer "linear", the linear best fit curve doesn't fit exactly the flux curve as pointed out by the regression quality factor (0.815 in the example). This effect is probably due to atmospheric air contamination.
If you obtain this kind of curve check the sealing of the accumulation chamber with the soil or check that tubes, filters and pump are intact.



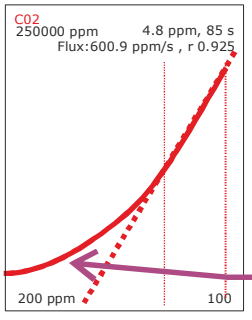
Gas stratification

This shape of curve indicates that the concentration of the target in air, close to the soil, is very high. This stratification is quite common in case of very high flux combined with a very stable atmosphere. You can use the measurement manually choosing (see DataRevision software) the second part of the curve for regression computation.



Low fluxes

This type of curve is normal when the flux is low and the "noise" of the detector is comparable with the increase of concentration.



Very high flux

The first part of the curve is not linear. The problem is due to the combined effect of the high flux and the sampling line cleaning. To avoid this increase the flux curve record time until the concentration of gas reaches the full scale value and select the last part of the curve for the flux computation.

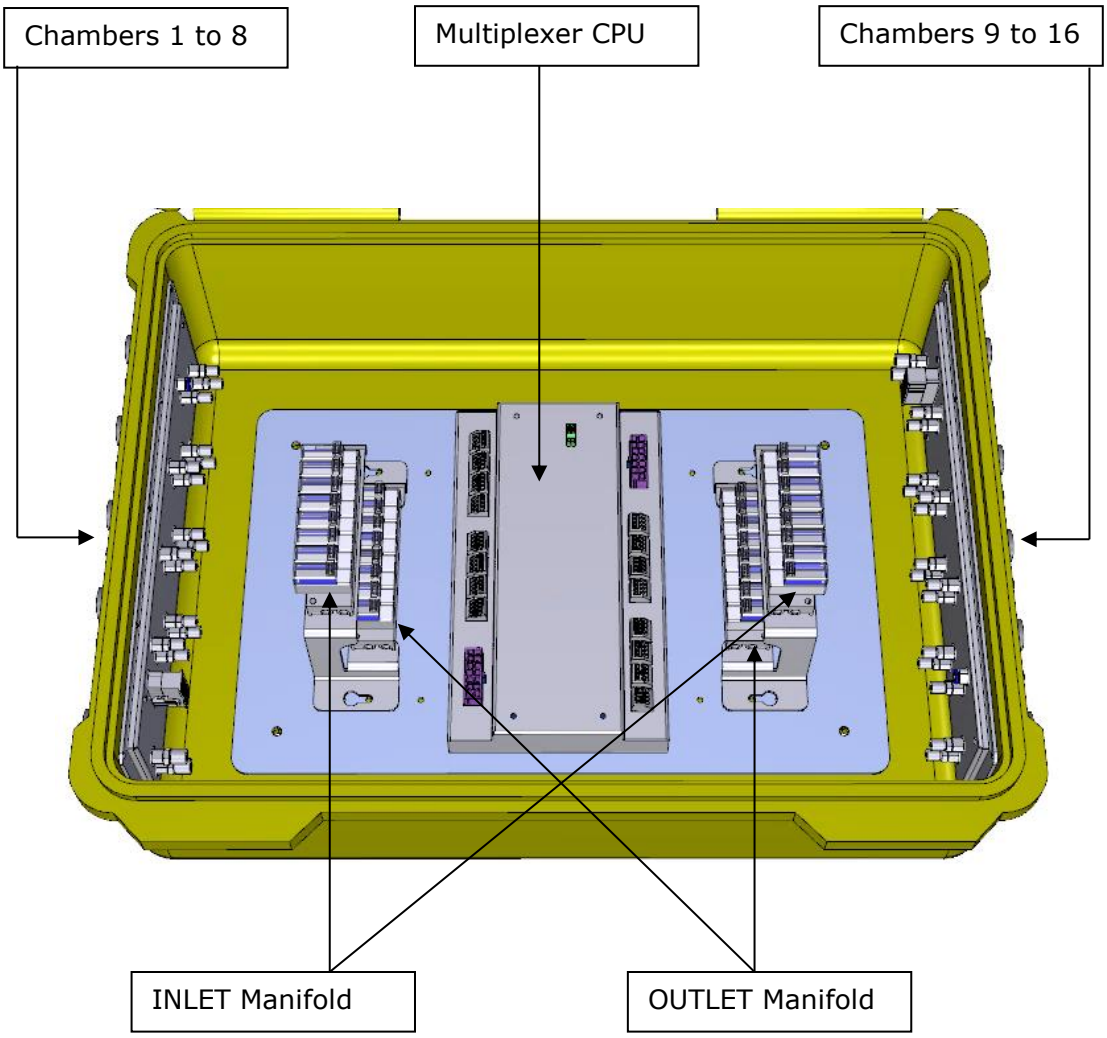
This effect is due to the cleaning of the sampling line dead volumes

6 The accumulation chamber

7. Multiplexer

7.1 Connections

The multiplexer allows the connection of up to 16 chambers to the station, 8 for each side.



Each one of the 16 ports are equipped with 2 electro-valves: one for the gas supply (from the chamber) and one for the gas return (to the chamber).
The electro-valves are collected in 8-port manifolds, for a total of 32 electro-valves.
The manifolds are installed on different levels, to simplify the maintenance of the system. The upper manifolds collect the INLET. The lower manifolds collect the OUTLET.
The tubes that connect the multiplexer INLET to the manifold are protected against dust with 0.20 micron PTFE filters (see Pneumatic circuit chapter).
A total of 16 filters are installed.

7.2 Configuration

The station doesn't recognize automatically the number of connected chambers (1 to 16), so if you connect or disconnect one or more chambers, you have to update the station's configuration:

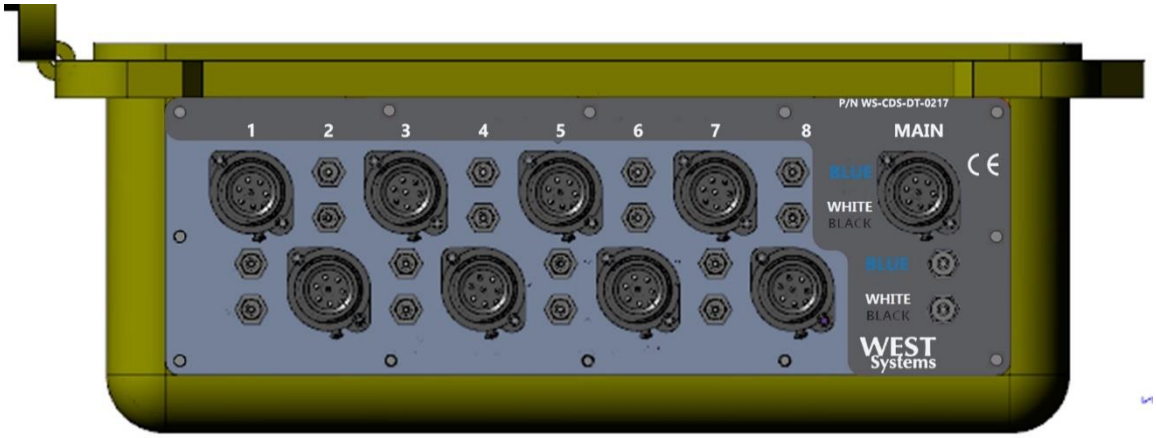
- Access to the station display
- Navigate to the command 3.1.9 SET CHAMBER NUMBER
- Input the number of chambers.

Please note that the flux station will sample sequentially from chamber 1 to the last chamber. The chambers must always be installed starting from port 1 and without leaving any gaps.

For example: with 5 accumulation chambers, the only working configuration is the following:

Port	Chamber
1	Chamber 1
2	Chamber 2
3	Chamber 3
4	Chamber 4
5	Chamber 5
6	NC
7	NC
8	NC
9	NC
10	NC
11	NC
12	NC
13	NC
14	NC
15	NC
16	NC

7.3 Connection Panel



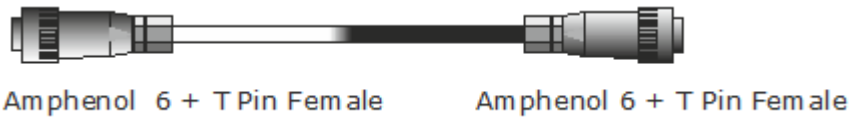
The multiplexer left panel contains the chamber ports from 1 to 8 and the MAIN port. The MAIN port is used to connect the flux station.

The multiplexer right panel contains the chamber ports from 9 to 16, and the AUX port. The AUX port is used to connect an auxiliary RS485 device, or a second multiplexer in cascade.

Each port (chambers from 1 to 16, MAIN and AUX) are composed by one electric and two pneumatic connectors:

- **RS485 connector**

  The socket is compatible with a standard West Systems RS485 cable:



RS485 Connector Pinout	
Pin	**Signal**
1	GND
2	RS485 A
3	RS485 B
4	GND
5	+12V NOT SWITCHED
6	+12V SWITCHED
7	NC

- **OUTLET PORT** (upper position). The ports 1 to 16 are compatible with a 4 mm external diameter / 2.5 mm internal diameter tube.
  The MAIN and AUX ports are compatible with a 6 mm external diameter / 4 mm internal diameter tube.

- **INLET PORT** (lower position). The ports 1 to 16 are compatible with a 4 mm external diameter / 2.5 mm internal diameter tube.

- The MAIN and AUX ports are compatible with a 6 mm external diameter / 4 mm internal diameter tube.

7.4 Testing the chambers

If the station is on measurement you can abort it (menu 1.4 STOP ANALYSIS) or wait till is finished.

1- Ensure that the number of connected chamber is properly configured (menu 3.1.9).
2- Go to menu 2.13 and select the first accumulation chamber.
3- Go to menu 2.1. Send the chamber up. At the end of the run, verify on the display the information is correct:

PXY UP ☑
PXY DN ☐

If the test fails, check the placing of the Open Switch: move the sensor closer to the chamber support until the on-board LED turns on.

4- Send the chamber down. During the run, both sensor must be off

PXY UP ☐
PXY DN ☐

At the end of the run, verify the Close Switch.

PXY UP ☐
PXY DN ☑

If the test fails, check the placing of the Close Switch: move the sensor closer to the chamber base until the on-board LED turns on.

5- Send the chamber up again and leave it open. Go to menu 2.3 and turn on the fan. Verify the fan is running. Turn off the fan.

6- Repeat steps 2-5 for all chambers.

7.5 Scheduler

Note that the continuous monitoring scheduler is active by default. Once the station is switched on, you don't need to take any actions to put the station into measurement.

The station performs flux measurement cyclically on the connected chambers.

With the default configuration (8 accumulation chambers; analysis frequency 600 seconds) an entire cycle will last 1h20 minutes. You'll have the following schedule:

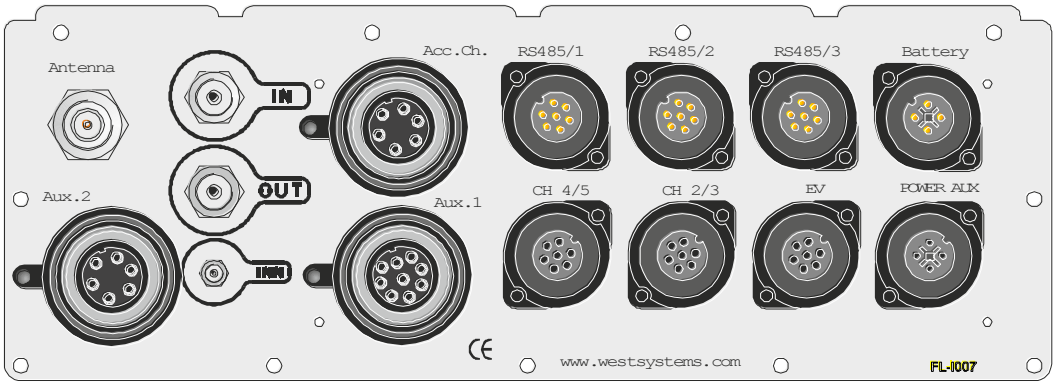
…

00:00	1st chamber flux measurement
00:10	2nd chamber flux measurement
00:20	3rd chamber flux measurement
00:30	4th chamber flux measurement
00:40	5th chamber flux measurement
00:50	6th chamber flux measurement
01:00	7th chamber flux measurement
01:10	8th chamber flux measurement
01:20	1st chamber flux measurement

7 Multiplexer

8. Flux station

8.1 Connection panel



Ports ***RS485 1/2/3*** are used for digital sensors. They're all connected to the same RS485 line so you can plug the digital devices (e.g. airbox, multiplexer, weather station) to any port indifferently.

Port ***Ch 2/3*** and ***Ch 4/5*** are used to connect additional sensors with analog output to the station. In the default configuration, channel 2 accepts current input (4-20 mA). Channels 3-4-5 accept voltage input (0-5 Volts). Note that channels 2 and 3 input are replied inside the case in the backplane ports.

Battery is the power input port. It's connected to the charge regulator or to a power supply.

Power AUX is a power output port. It can be used to power any device with the same power input that comes from the Battery port.

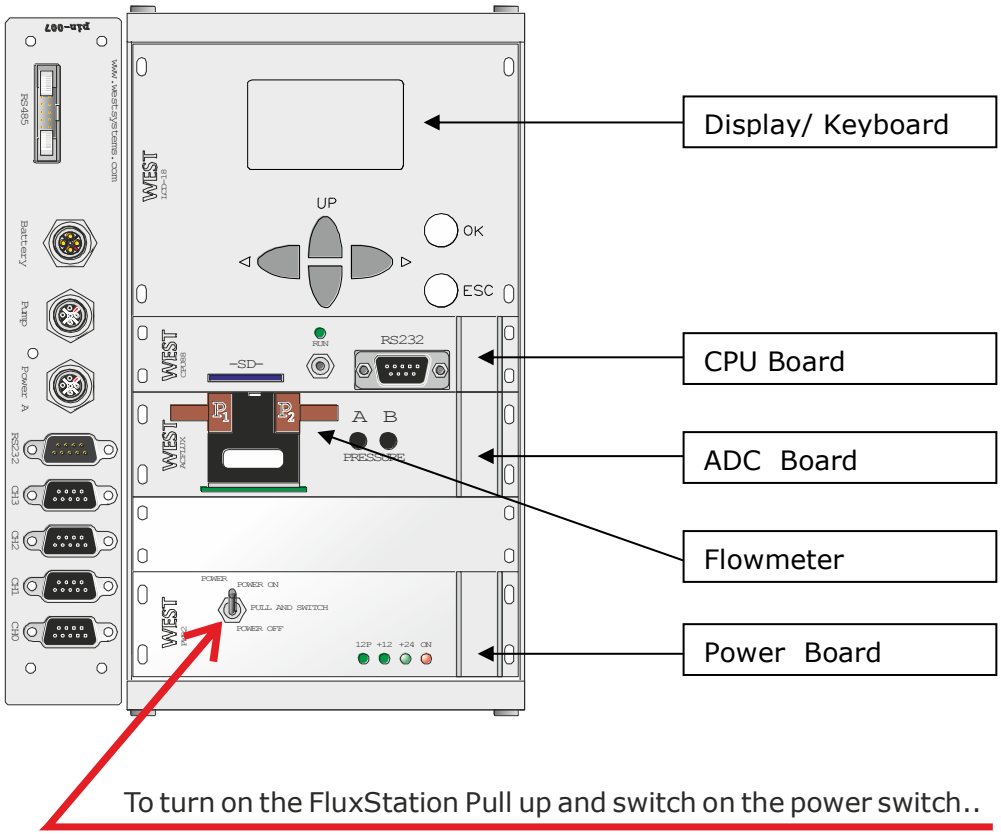
EV is the digital output port. The station has 4 digital output signals that can be configured to turn on or off at a certain moment of the flux analysis.

Acc Ch. and ***Aux.1*** ports are used to connect an analog accumulation chamber.

Antenna port is used to connect an external antenna, if needed. Type is N-female.

Aux. 2 port contains an Ethernet socket, protected by a cap against dust and water. The Ethernet port is connected directly the Modem-Router LAN port. The Aux.2 port can be used to communicate to the flux station without having to open the station. A laptop with an Ethernet port is needed.

8.2 Backplane

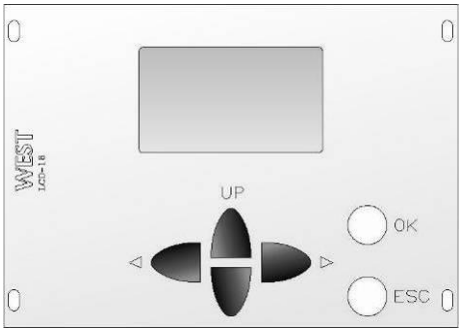


The flux station electronics is composed by 4 boards:

- Display and keyboard.
- The CPU Board manages the analysis, the storage of data and the communication with the outside.
- The ADC Board managed the 24-bit Analog-to-Digital conversion of the 8 analog channels.
- The Power Board provides the 12V and 24V channels, necessary to the functioning of the sensors and the devices.

8.3 Display

The station is equipped with a LCD monochromatic display for configuration and testing of the sensors.

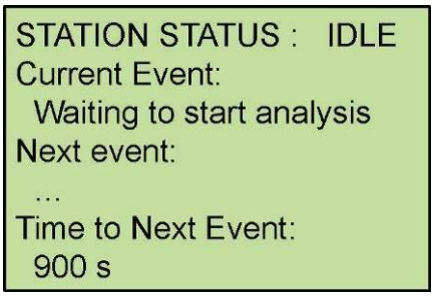


Readable surface: 5.1 cm X 3.1 cm
Input: 6 buttons (up, down, left, right arrows, OK, ESC).

The display is kept usually off in order to minimize power consumption. To wake it up, press the "RUN" button.
At the startup, the display will show the West Systems logo. If no buttons are pressed, the display will remain in this state. Otherwise after 2 seconds the main menu will be showed.

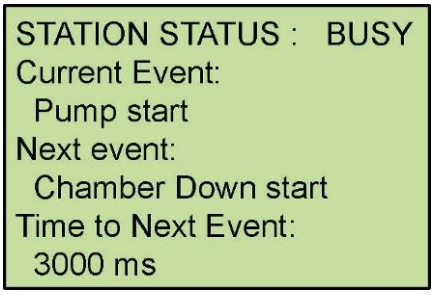
Pressing ESC from the main menu, a frame will show the current status of the station, the next status and the remaining time.

Example 1:



The station is waiting for the next measurement that will start in 15 minutes.

Example 2:



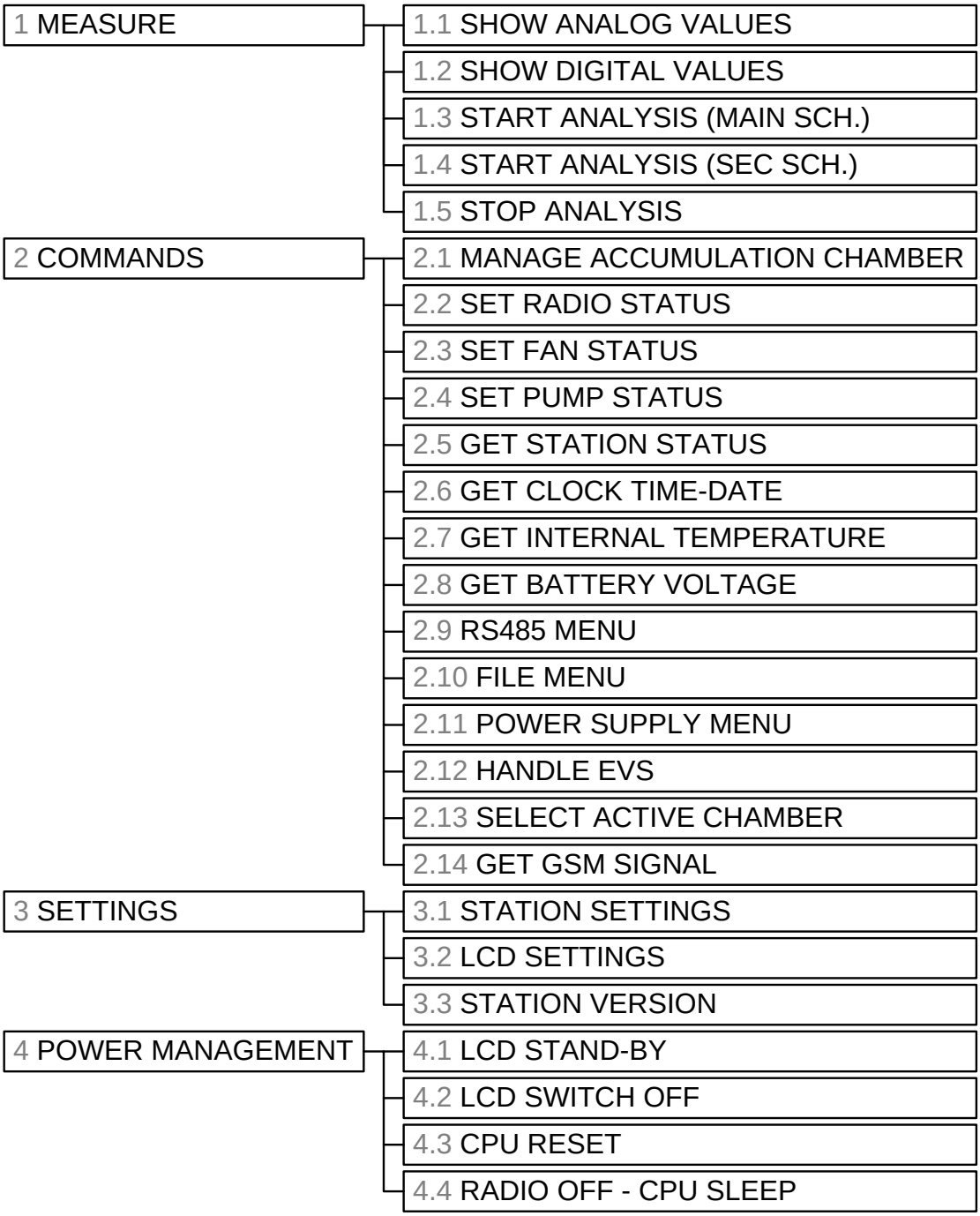
The station is performing the measurement cycle. The last action was starting the pump. In 3 seconds the chamber will start closing.

Press any key to return to the main menu.

General menu and keyboard rules:

- To enter onto a submenu: Select the 'Entry' and press OK.
- To exit from a submenu: - Select 'Back' and press OK.
  or
  - Press ESC.
- To navigate between multi pages submenu:
  - Select 'Prev page' or 'next page' and press OK.
  or
  - Press LEFT for previous page or RIGHT for next page.

8.4 Menu structure



When you're finished your job, you can turn off the LCD display with the menu POWER MANAGEMENT and then LCD SWITCH-OFF, but it is not usually necessary because the display will automatically shut down after a certain amount of time (configurable in LCD SETTINGS menu).

[1 MENU MEASURE]

[1.1 SHOW ANALOG VALUES]
The real-time readings of the 8 analog channels are displayed. The analog channels are the ones connected to the internal Backplane (for example the CO2 detector, the Vaisala pressure sensor, the flowmeter) or plugged to the external connector (CH 2/3 and CH 4/5).

[1.2 SHOW DIGITAL VALUES]
The real-time readings of the digital channels are displayed. The digital channels are the ones connected to the RS485 chain. Their number is variable from 0 to 31.

[1.3 START ANALYSIS (MAIN SCH.)]
Start one cycle of measure using the Main Scheduler. The cycle starts from the lower timing (usually "+24 ON") and ends with the higher one (usually "radio off" or "write file"). This command executes manually what is automatically executed by the scheduler (for example every hour).

[1.4 START ANALYSIS (SEC. SCH.)]
Start one cycle of measure using the Secondary Scheduler (if enabled). The cycle starts from the lower timing (usually +24 ON) and ends with the higher one (usually radio off). This command executes manually what is automatically executed by the scheduler (for example every hour).

[1.5 STOP ANALYSIS]
Stop the current analysis if it's running. So the station will remain in idle mode until another measure is started manually or by the scheduler.

[2 MENU COMMANDS]

[2.1 MANAGE ACCUMULATION CHAMBER]
The accumulation chamber is equipped with 2 proximity sensor to evaluate remotely if the chamber can close and open without obstacles. This page shows the current status of the proximity sensors on the accumulation chamber. Press and release the up and down arrows to start moving the chamber. Press Ok to stop. When the chamber is fully opened, you should see "PXY UP" ON the other OFF. While the chamber is going up or down you should
see both proxies off and when the chamber is closed you should see the "PXY DN" ON and the other OFF. If you see both "PXY DN" and "PXY UP" the chamber is not working or the proximity sensors are not well placed. See chapter 5 for more details.

[2.2 SET RADIO STATUS]
Allows to temporarily switch ON and OFF the radio. Then when a measure will start, the radio will return to be managed by the station. To set the radio always ON, you have to modify the event timings (set Radio ON e Radio Off to 0, see chapter 10 for more details)

[2.3 SET FAN STATUS]
Allows to temporarily switch ON and OFF the accumulation chamber mixing fan. Then when a measure will start, the fan will return to be managed by the station.

[2.4 SET PUMP STATUS]
Allows to temporarily switch ON and OFF the pump. Then when a measure will start, the pump will return to be managed by the station.

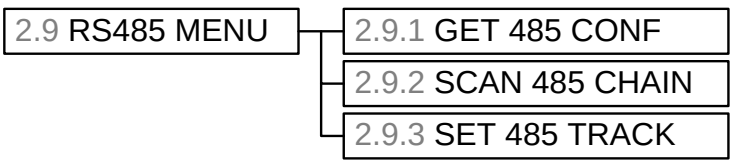
[2.5 GET STATION STATUS]
Show the status of the station and the current event of the measure (if 0 a measure is not running).

[2.6 GET CLOCK TIME-DATE]
Shows the station internal date and time. It's very important that this clock is correct because the measure files that will be recorded will be marked with this date. A wrong clock could make useless all the saved data. However the clock is automatically synchronized every time the master centre computer is able to communicate with the station (we advise furthermore to set the master centre personal computer to automatically synchronize its clock every day from a time server, e.g. time.windows.com). If the telemetry or the master centre are not active, synchronize the clock manually, using the [SET CLOCK DATE] and [SET CLOCK TIME] functions in the menu [SETTINGS].
Note: the clock is powered by the station or, when the station is switched on, by a 3V battery on the CPU board. If the station remains off for a large amount of time, the 3V battery will run down and the station clock will reset to January 1, 2000. In both cases, the clock integrated in the station is not so accurate (it could lose or gain even 1 or 2 seconds per day). So consider that if the station remains isolated (not interrogated by the master centre) for a large period of time, the date of the measures will derive.

[2.7 GET INTERNAL TEMPERATURE]
Show the station internal temperature.

[2.8 GET BATTERY VOLTAGE]
Shows the battery status. Since the battery is recharged by a solar panel, the voltage should fluctuate reaching the maximum value on the afternoon and the minimum at dawn. A value lower than 10 Volts is critical and the station could shut down.

[2.9 RS485 MENU]



[2.9.1 GET 485 CONF] shows the list of connected RS485 sensors.
The following fields are displayed:
- ID: hexadecimal view of the sensor ID in the RS485 chain
- Name: description of the sensor

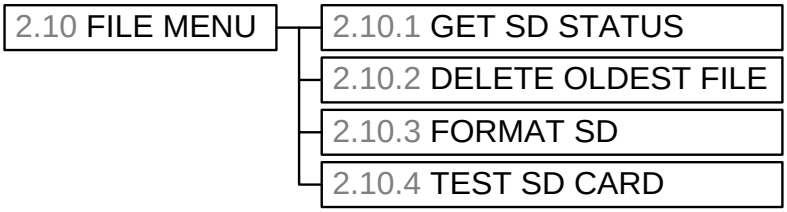
- Track On/Off: if you select Track=On a curve will be acquired for the selected channel. Otherwise only one sample per sensor will be saved. If one or more sensors are connected but they're missing on the list you should execute a RS485 SCAN.

[2.9.2 SCAN 485 CHAIN] update the list of digital sensors connected to the station. Perform this action if you added a new digital sensor, as SoilBox and AirBox. An RS485 scan will take several minutes.

[2.9.3 SET 485 TRACK] allows to set/unset the track of the sensor (see GET RS485 CONF). First select the sensor you'd like to set and then select ON or OFF.
This operation can be also executed remotely with Scada (allows to change the track of all channels, both analog and digital):

- Select "Get channels' configuration" and then "Call now".
- Open the table "PhisicalChannels" on the database
- Set the "PlotCurve" field of the corresponding row to 0 if you want to disable the track or to -1 if you want to enable it. Close the database.
- Select "Set channels' configuration" and then "Call now".

[2.10 FILE MENU]



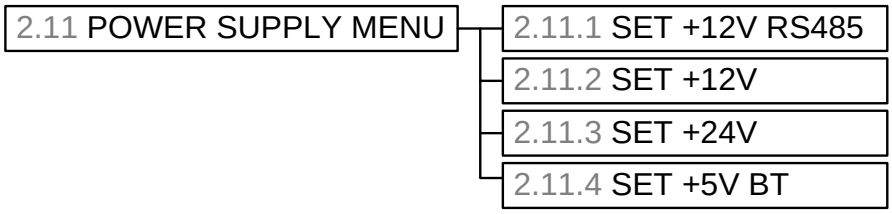
[2.10.1 GET SD STATUS] checks if the SD card is working and retrieves information about the capacity, space left and number of files on device. This process could take several minutes.

[2.10.2 DELETE OLDEST FILE] removes from the SD card the oldest file. It's the same operation done by Scada when a file is successfully downloaded.

[2.10.3 FORMAT SD] executes the memory card formatting. Warning: this operation will erase all the recorded data. Don't execute this command unless you want to empty the card.

[2.10.4 TEST SD CARD] executes a deep read/write access to the SD card. If this test is passed, we can be sure the SD is working fine. The same test is executed every time the station is switched on. We strongly advice to make this test every time you insert a new memory card, to make sure not to use damaged or unsupported SD card (example: SDHC).

[2.11 POWER SUPPLY MENU]



[2.11.1 SET +12V RS485]

Allows to temporarily switch ON and OFF the 12 Volt RS485 power supply (which powers the RS485 detectors like airbox and soilbox). Then when a measure will start, the supply will return to be managed by the station.

[2.11.2 SET +12V]

Allows to temporarily switch ON and OFF the 12 Volt power supply (which powers for example the barometric pressure probe, the flowmeter). Then when a measure will start, the supply will return to be managed by the station.

[2.11.3 SET +24V]

Allows to temporarily switch ON and OFF the 24 Volt power supply (which powers for example the CO2 detector). Then when a measure will start, the supply will return to be managed by the station.

[2.11.4 SET +5V BT]

Allows to temporarily switch ON and OFF the 5 Volt power supply (which powers for example the BlueTooth module). Then when a measure will start, the supply will return to be managed by the station.

[2.12 HANDLE EVs]

Allows to read and set the status of the digital output EV0, EV1, EV2, EV3.

[2.13 SELECT ACTIVE CHAMBER]

(Only in multi-chamber mode) This command selects one of the accumulation chambers on the multiplexer. When a chamber is selected, the actions you call on the station (motor up, motor down, fan on) are forwarded to the active chamber, and the sampling line is switched.

[2.14 GET GSM SIGNAL]

Allows to check the GSM signal quality (if a GSM/GPRS modem is connected).
To check the signal of GSM network, follow the procedure:

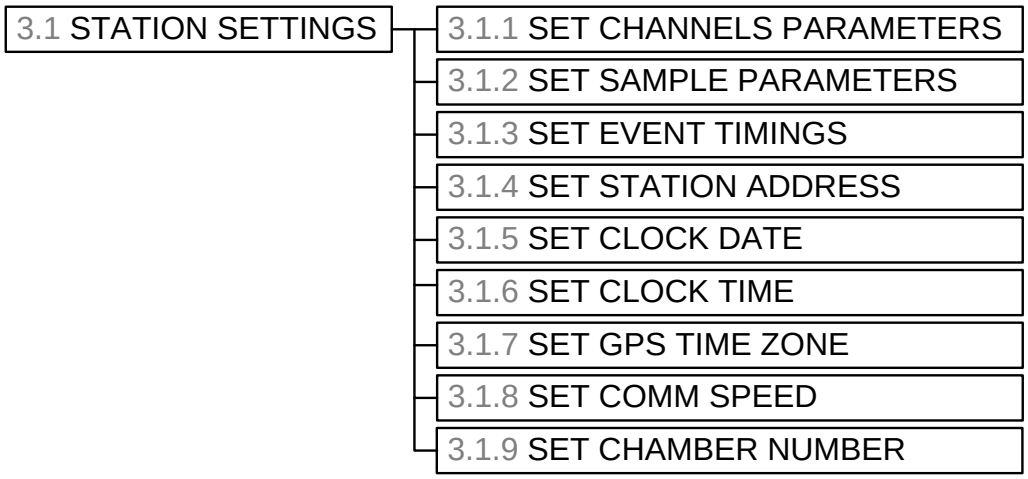
- Turn on the GSM modem (menu 2.12 Handle EV, then activate EV3)
- Get back to GSM menu (2.14). The display will show a couple of numbers separated by a comma

The first number is the RSSI (Received signal strength indication). It has the following meaning:

0: –113 dBm or less
1: –111 dBm
30: –109 to –53 dBm
31: –51dBm or greater
99: not known or not detectable

The second number is the BER (Bit Error Rate).
You may need an RSSI greater than 20 to have a good communication with the master center.

[3 MENU SETTINGS]



[3.1.1 SET CHANNELS PARAMETERS]

Allows to modify the settings of the analog channels. Use the left and right arrows to move from the channel 0 to 7. Use the up and down arrows to move between the fields of one channel. Press OK to edit selected field. You can modify the following parameters:

- Conf: Is the type of channel, and it defines the way the station translate an analog input to a readable measure unit.

  Valid Conf are:

  - FF05: the output of sensor connected to the channel is 0-5V and the station will consider 0 V equal to the "Low Scale" value and the 5 V equal to the "Full Scale" value.
  - FF06: the output of sensor connected to the channel is 4-20 mA and the station will consider 4mA equal to the "Low Scale" value and the 20 mA equal to the "Full Scale" value.
  - FF07: the output of sensor connected to the channel is 1-5V and the station will consider 1 V equal to the "Low Scale" value and the 5 V equal to the "Full Scale" value.
  - FF0F: special Conf. reserved to the P.Flow sensor (AWM3300). A special trasfer function is applied to this channel to linearize the answer. Since an hardware adjustement is necessary to change the input from current to voltage these field must considered read only.

- Name: is a description of the channel, to help the operator.

- Gain/Offset: the reading of the channel can be calibrated using these 2 parameters as result of the formula: y=ax+b where x = original value, a = gain, b = offset, y = calibrated value. Use the Gain/Offset to correct the answer of a detector. Default values are Gain=1 Offset = 0. These values leave the original reading.

- Offset: See Gain.

- Low Scale/Full Scale: see Conf. Usually you will need to change those parameters only if you change a sensor of if you modify its measurement range. Instructions to change the detector full scale are reported in the following pages.

- Track: If you select Track=On a curve will be acquired for the selected channel. Otherwise only one sample per sensor will be saved.

[3.1.2 SET SAMPLE PARAMETERS]
Allows to set the number of samples that will be recorded for a curve (default: 120) and the time interval between 2 samples (default: 1000 milliseconds). Note: if you want to enlarge the sampling window by increasing one of those 2 parameters, you have also to modify the timings (for example to shift the time of the pump power off or of the chamber rise). Don't hesitate to contact West Systems support before to perform those operations.

[3.1.3 SET EVENT TIMINGS]
Allows to set the station event timings. Use left and right arrows for fast scrolling. Those settings allow to manage the frequency of the measures and the analysis cycle . Those parameters can also be accessed in remote by calling in Scada "Get station parameters" and opening the table "HWR7_Parameters" of the database scada_data.
Modifying the timings is a delicate operation so don't hesitate to contact West Systems support before.
The event timings (timings from 1 to 31 included) are those timings that regulate at what instant a certain event is executed. All event timings are relative to the start of the analysis cycle.
For example if the timing 7 (event Pump On) is set to 120000, the pump will start 2 minutes after the start of the cycle.
Scada furnishes (menu "Edit station parameters") a simplified interface to set all the timings starting from the wanted settings.
For example if you desire a Warm-Up time of 10 minutes, Scada will automatically delay all the following events. See chapter 10 for more details.
The following list described the meaning of the timings:

ID	Description	Default	Note
0	analysis frequency (sec)	3600	If equal to 0, a measure will start only manually, the scheduler is not active.
1	event +24 on	1	
2	event +24 off	323000	
3	event start chamber down	140000	
4	event end chamber down	160000	
5	event start chamber up	283000	
6	event end chamber up	303000	
7	event pump on	120000	
8	event pump off	323000	
9	event fan on	120000	If set to 0, the station will never start the mixing device.
10	event fan off	323000	
11	event +12 on	1	
12	event +12 off	323000	
13	event start conversion	161000	From this moment the station will record the samples. The sampling will last for a number of seconds equal to Numsamples X DeltaT (for example 120 X 1000msec = 2 minutes).
14	event all off	324000	
15	event get rs485 sample	304000	
16	event write file	325000	Must be last event (except for Radio On and Radio Off).
17	not used	0	
18	not used	0	
19	not used	0	
20	not used	0	

ID	DESCRIPTION	DEFAULT	NOTE
21	not used	0	
22	not used	0	
23	not used	0	
24	not used	0	
25	not used	0	
26	not used	0	
27	not used	0	
28	not used	0	
29	not used	0	
30	event radio on	600	If equal to 0, the station will never go in sleep mode (radio always on).
31	event radio off	900	If equal to 0, the station will never go in sleep mode (radio always on).

[3.1.4 SET STATION ADDRESS]
Allows to set the station address. The default station address is 0001. There are 65535 possible addresses from 0001 to FFFF. If you have more that a station on the same network, it's strongly advised to assign a different address to every station, in order to prevent Scada to download data from the wrong station. However this parameter is set in the factory so you won't need to perform this operation. A station will respond only to the request having the correct address. Changing the station address without configuring also Scada will result in the impossibility of the communication with the master centre. It corresponds on the database to the StationIP field of the table Stations.

[3.1.5/6 SET CLOCK DATE / SET CLOCK TIME]
Allows to set the internal clock of the station. It's very important that this clock is correct because the measure files that will be recorded will be marked with this date. A wrong clock could make useless all the saved data. However the clock is automatically synchronized every time the master centre computer is able to communicate with the station, so use this operation only if the telemetry is down.
We advise furthermore to set the master centre personal computer to automatically synchronize its clock every day from a time server (like time.windows.com).
Note: the clock is powered by the station or, when the station is switched on, by a 3V battery on the CPU board. If the station remains off for a large amount of time, the 3V battery will run down and the station clock will reset to January

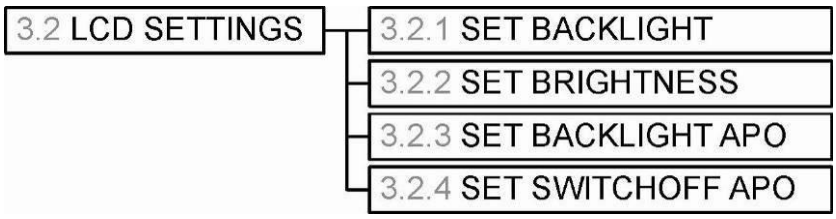
1, 2000. In both cases, the clock integrated in the station is not so accurate (it could lose or gain even 1 or 2 seconds per day). So consider that if the station remains isolated (not interrogated by the master centre) for a large period of time, the date of the measures will derive.

[3.1.7 SET GPS TIME ZONE]
This section allows to change time zone when the GPS device is available. In this case the station clock is synchronized with GPS Time shifted by the time zone selected.

[3.1.8 SET COMM SPEED]
This section allows to change the baud rate settings of the serial ports. It is a very delicate operation that will be needed only in particular circumstances, so we strongly advise not to change this parameters because this will interrupt the communication with the master centre or with the digital sensors.

[3.1.9 SET CHAMBER NUMBER]
Allows the setting of the number of accumulation chambers that are connected directly to the station (1 chamber) or to the multiplexer (from 2 to a maximum of 16).

[3.2 LCD SETTINGS MENU]



[3.2.1 SET BACKLIGHT]
Allows to regulate the power of the LCD backlight.

[3.2.2 SET BRIGHTNESS]
Allows to regulate the brightness of the LCD.

[3.2.3 SET BACKLIGHT APO] (Auto Power Off)
Allows to set the time interval after which if any of the buttons will be pressed the station will switch off LCD backlight.

[3.2.4 SET SWITCHOFF APO] (Auto Power Off)
Allows to set the time interval after which if any of the buttons will be pressed the station will switch off the display.

[3.3 STATION VERSION]
Displays the serial number of the station and the firmware version of the station.

[4 MENU POWER MANAGEMENT]

[4.1 LCD STAND BY]
The display is temporarily switched off. It can be awaken by pressing the OK button.

[4.2 LCD SWITCH OFF]
The display is turned off and will be turned on again only when the CPU wakes up from a sleep state (or obviously if you switch on the station again). This operation doesn't affect the station behavior, only the LCD display will be shut down.

[4.3 CPU RESET]
Reset the CPU. This operation corresponds to switching off and on the station.

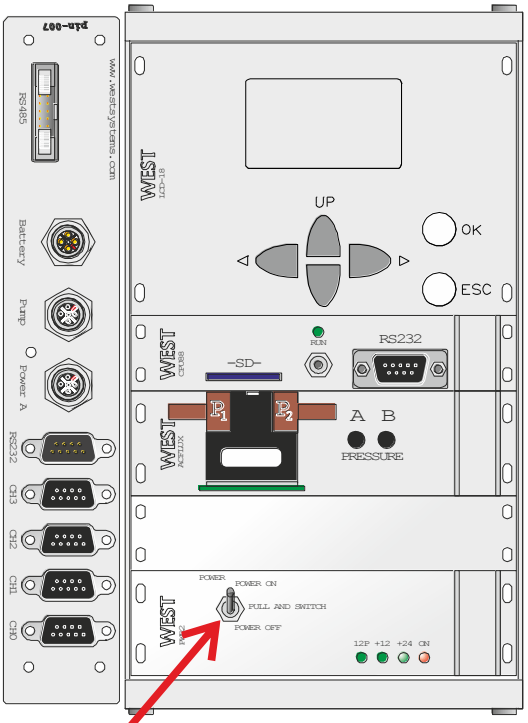
[4.4 RADIO OFF - CPU SLEEP]
Put the CPU in sleep mode. While in sleep mode, the station is like switched off, except for the fact that it will be woke up by its internal alarm clock or by pressing the CPU run button. It's the state of minimum power consumption.
The station goes to sleep mode in the following circumstances:

- After writing a file to the SD card: it will wake up at the event Radio ON (if different from 0) or at the next measure.
- After Radio Off: it will wake up at the next measure
- When Scada has finished interrogating the station, sending a specific command.
- Through this command on the LCD display.

.

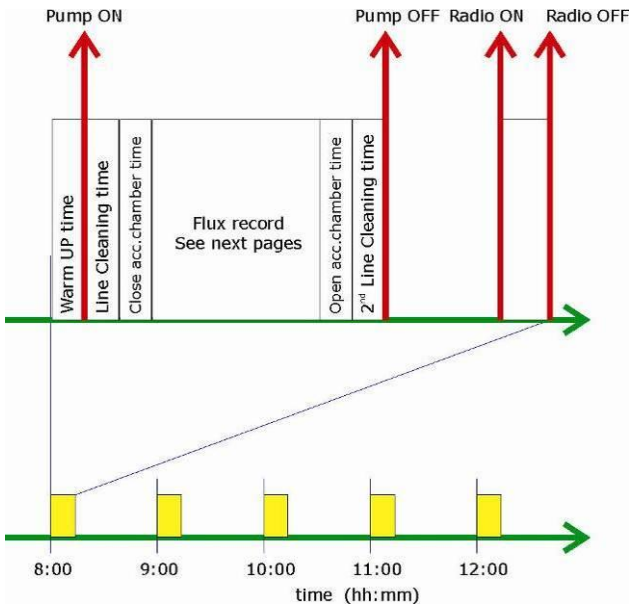
9. Running FluxStation

9.1 Quasi-continuous monitoring



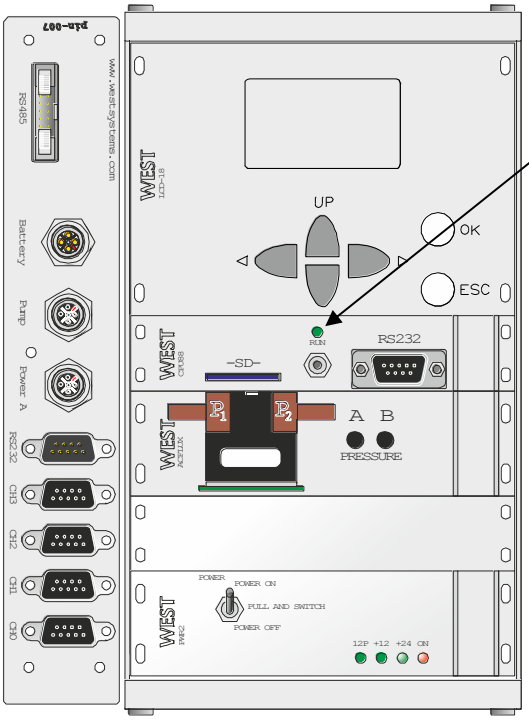
To turn on the FluxStation Pull up and switch on the power switch..

After a quick boot the station starts the quasi-continuous monitoring task. There is no need to manually activate the measurements. The next measurement will start automatically according to the Analysis Every timing.



If a multiplexer is connected, a measure is started sequentially on each chamber (see multiplexer annex).

Following the default configuration parameters the station performs one analysis cycle every hour (By default). See chapter 5.



CPU RUN LED/BUTTON:

- If the LED is off, the station is in sleep mode. To wake up, press the same button
- If the LED is blinking every 2 seconds, the station is running
- If the LED is on, the station is going to write the file to the SD card (it's a warning to wait replacing the card

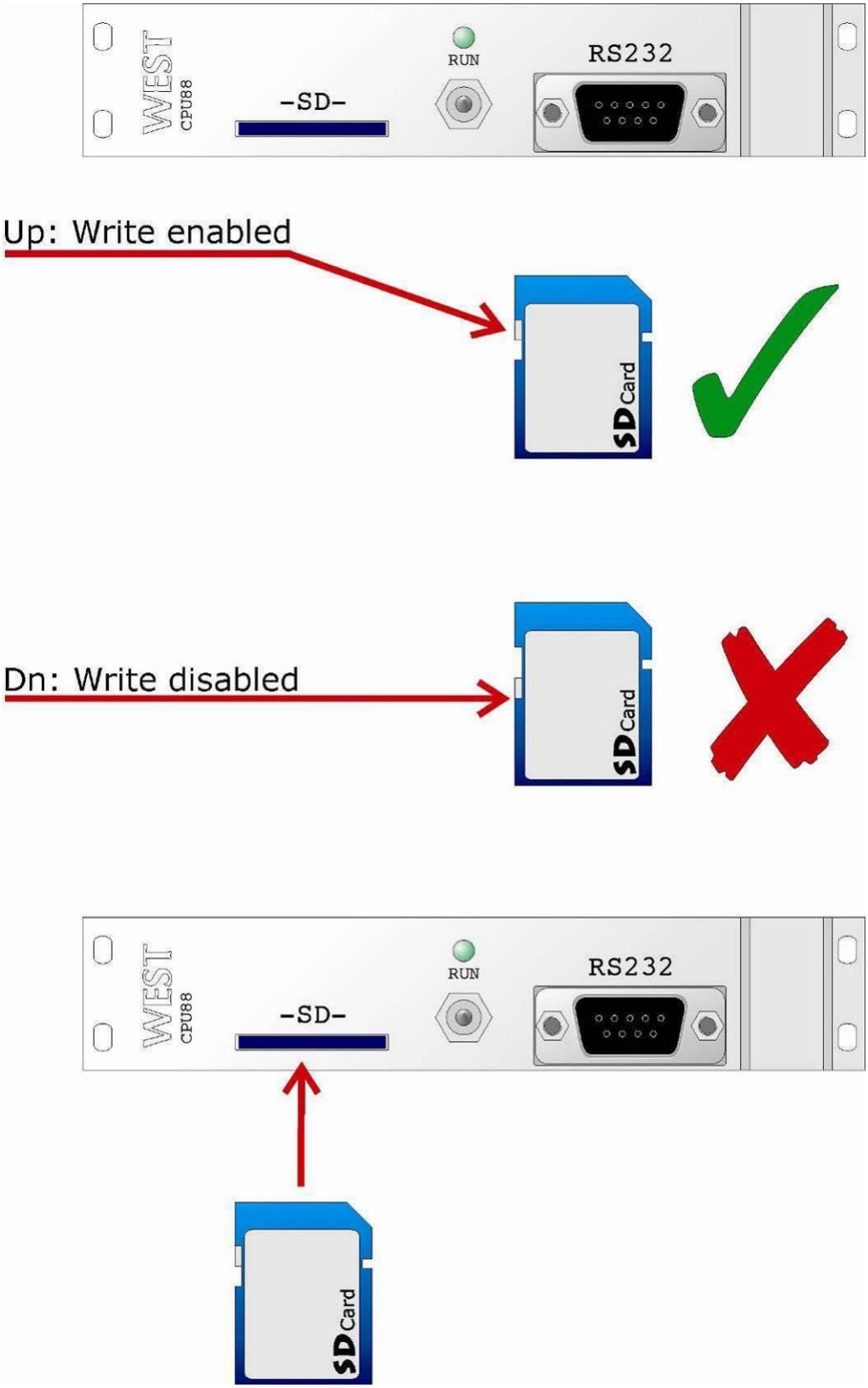
The station stores the result of analysis cycles on a SD memory card. The SD card is formatted using the FAT32 file system and can be read directly from any PC.

Each analysis cycle requires a couple of kilobytes on the SD card (it depends on the number of tracks and the number of samples per track), but due to the file system the "disk dimension" of file is 4 KBytes. Then for the default sampling frequency (one measure every hour) are necessary 96 KB/day (35 MB/year). An SD card with 1 GB capacity will store data for 28 years.

But if the station is regularly interrogated, the SD card will contain only 1 file at once, because as Scada downloads a file and saves it on the Database, commands the station to remove the file from the SD card.

Note: the station is NOT compatible with High-Capacity (SDHC) cards.
Please use standard SD cards (capacity up to 2 GB).

Before to insert the SD memory card in the CPU slot verify that the Write On/Off switch of the card is in the enabled position.



After inserting the SD card check if it's working correctly making a read/write test though the menu [2.10.4 Test SD Card]

This menu displays also the space left on device.

The station writes on the card at the end of the measurement cycle. Removing the card during the cycle can cause the loss of data.

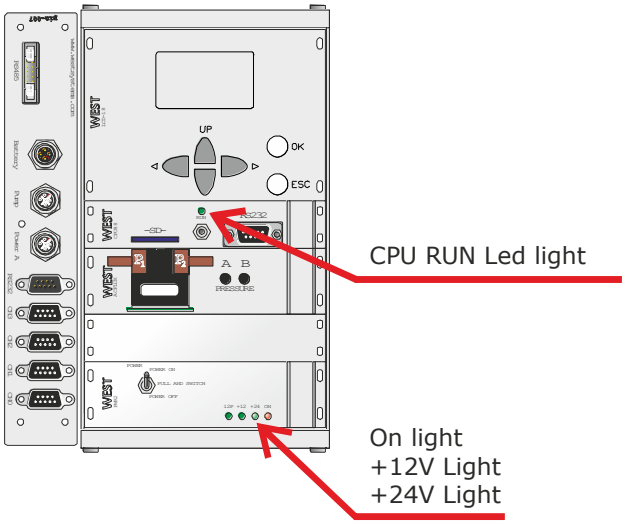
In order to inform the operator of the next writing operation, the CPU run led light will be solid ON for a 60 second period before starting to write on the card.

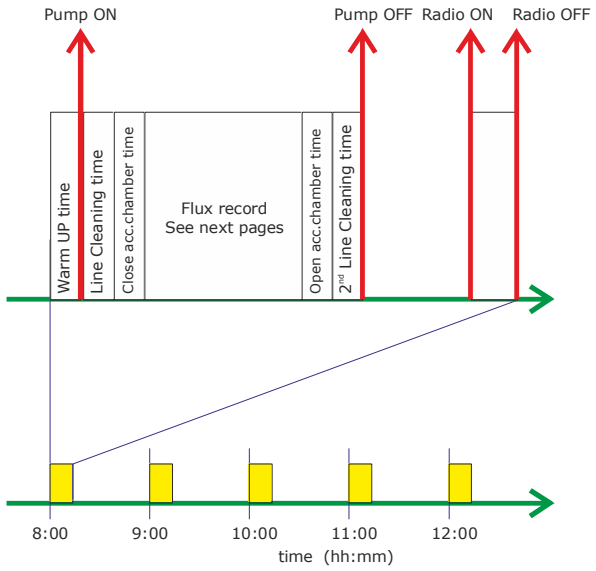
Then if you have to swap the card on the FluxStation you've to:

- Prepare the empty SD card. The SD card has to be not SDHC. High Capacity cards are NOT compatible with the station. The card has to be formatted with FAT32;
- Check that the "CPU RUN LED" is flashing once every 2 seconds or that it's OFF;
- Remove the card on the slot;
- Place the empty card in the slot.

If you want to be sure the card is correctly inserted and functional, execute a read-write test: menu [COMMANDS][FILE MENU][TEST SD CARD].

9.2 Station Status





The station has two working states:

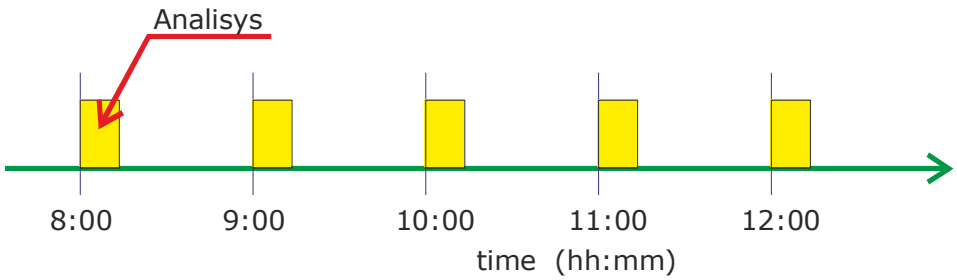
1) Standby: the time between the analysis cycles;

2) Analysis cycle (Yellow boxes in the drawings).

Stand-By State
During the stand-by state the CPU RUN led light, on the CPU board, flashes once per second and the ON light on the Power board is solid ON.

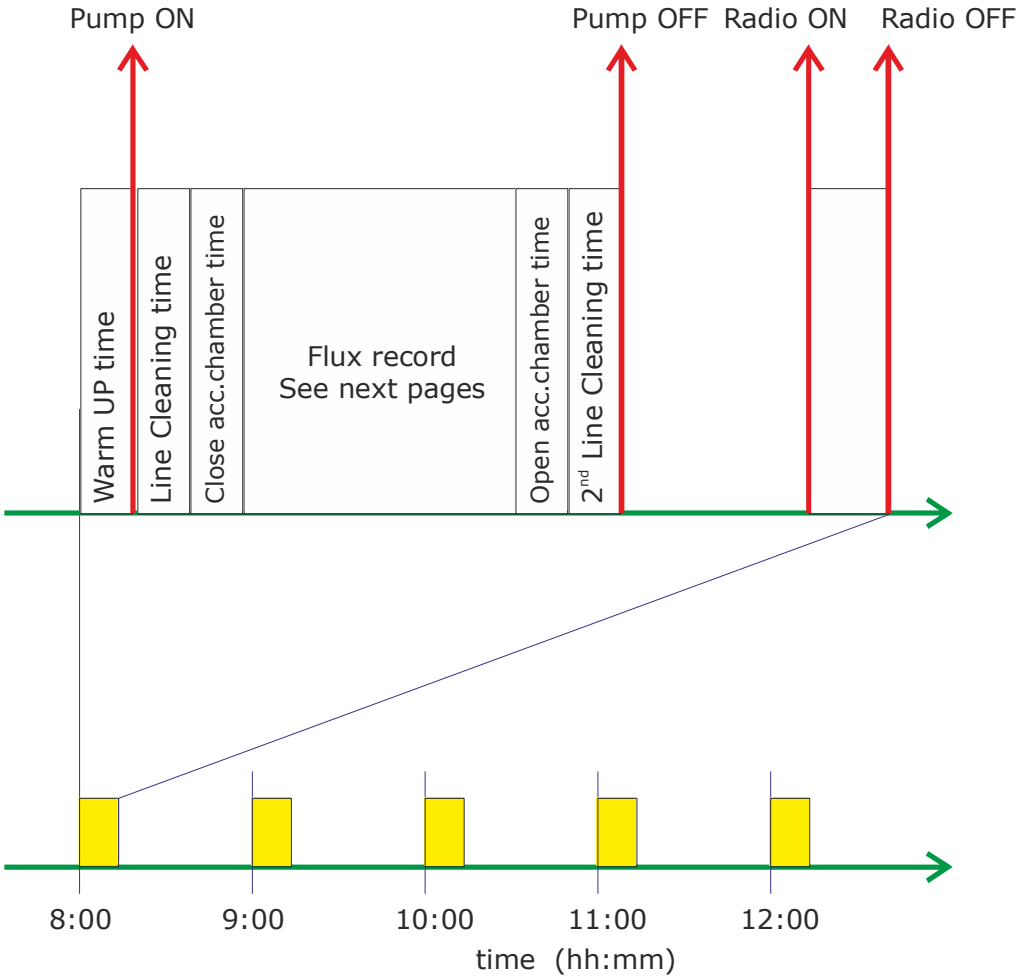
Analysis running state
While the analysis cycle is running the CPU RUN led light, on the CPU board, flashes once per second and the ON light on the Power board is solid ON. The +12V and +24V led light are solid ON (or OFF) depending on the phase of the analysis.

Analisys every time
It's the interval between analisys. Normally the station makes an analisys every hour and then the default value of the parameter is 3600 sec;
Valid range 300 .. 7200 seconds;
If the time between analisys is 3600 secs (1 hour) the analisys will start exactly at the beginning of hour, for instance the sampling time will be 8 sharp, 9 sharp ect.



Every measurement cicle (analysis) is composed by several actions that are scheduled by some parameters described below.

9 Running Flux Station

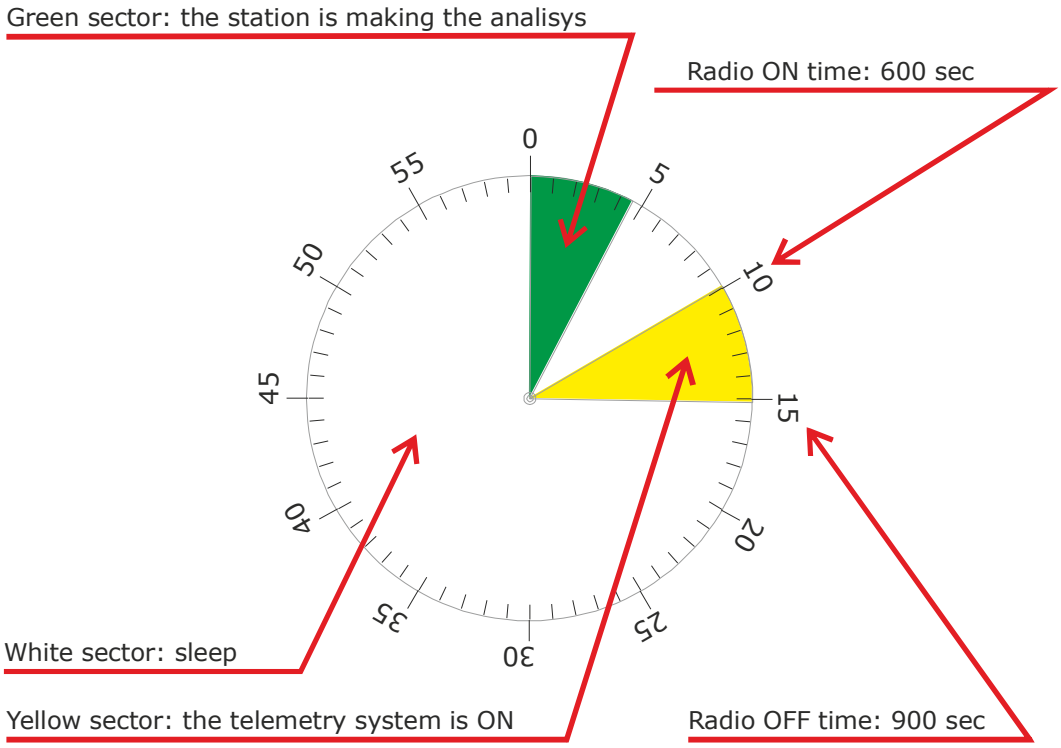


Set RADIO On/OFF:
When the instrument runs on batteries, in order to reduce the power consumption the telemetry system can be managed as follow:

- RADIO On time (sec)
The telemetry system will be turned ON after every analysis starting from the time, expressed in minutes, you set.

- RADIO Off time (sec)
The telemetry system will be turned OFF after every analysis starting from the time, expressed in minutes, you set.

If Radio Off Time or Radio On Time are set to 0, the station will keep the radio ALWAYS ON and will never go to sleep mode.
This is the default setting when the station is powered by the mains electricity.



In the drawing an example of
Radio On time = 600 (sec)
Radio Off time = 900 (sec)

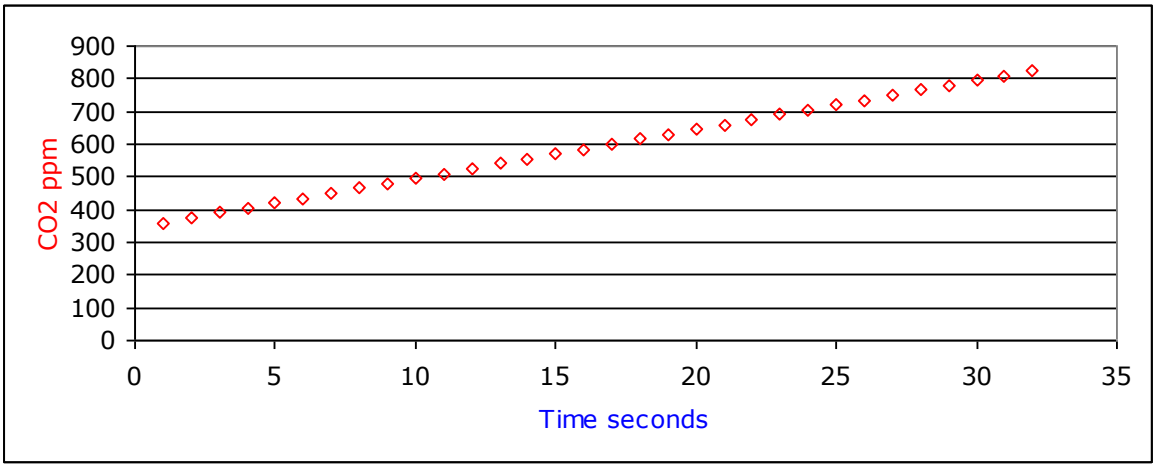
Num. Samples: Is the number of points in the flux record. Normally the value is between 32 and 256 points. The increase of this parameter will increase the size of the record, reducing the capability of station data storage and increasing the data transmission time.

Delta T.: Is the time , expressed in millisecond, between the points sampled in the flux record.
Normally the value is between 500 (0.5 seconds) and 3000 (3 seconds)

The global flux record time is **: Delta T. x Num. Samples/ 1000**

In the following plot a sample of flux record with Num of Samples = 32 and DeltaT. = 1000 (1 second). The overall flux record length is 32 second.

9 Running Flux Station



The normal record length must be in the interval 90 .. 240 seconds. If the flux is quite high the length can be 90 seconds, is the flux is quite low is better to increase the record length

10. Calibration

10.1 Calibration of the LI-COR LI820

The subjects regarding calibration of your instrument for the measurement of diffuse flux will be discussed in this chapter.

As explained previously the flux measurement is proportional to the slope of the concentration curve versus time. The proportionality factor depends on the volume/surface ratio of the accumulation chamber used for the measurement, as well as, the barometric pressure and air temperature at the time of the measurement.
The most important aspect to understand is that the flux is proportional to the gradient of concentration over time: ppm/second.
This aspect allows us to simplify the control of the response of the gas sensors.

When to calibrate

The recommended calibration interval is one year. The operating conditions affect the long-term stability. In a harsh operating environment, it is recommended to check readings more often than in easy environments.

What you need in order to check the calibration

- A cylinder of nitrogen or CO_2-free mixture.
- A cylinder of standard mixture of a known concentration of carbon dioxide in air (or nitrogen) *;
- Two Tedlar gas sampling bags, of 5 or 10 liters capacity.

* The carbon dioxide concentration should be between 50% and 95% of the detector measurement range. If the full-scale value of the detector is 20,000 ppm, you can use a standard with a concentration of CO2 between 10,000 and 19,000 ppm. If the concentration is less than the 50% of the full-scale value, you will increase the calibration error.
If the full scale of the detector is 1,000 ppm, you can use a standard with concentration of CO2 between 500 and 950 ppm.

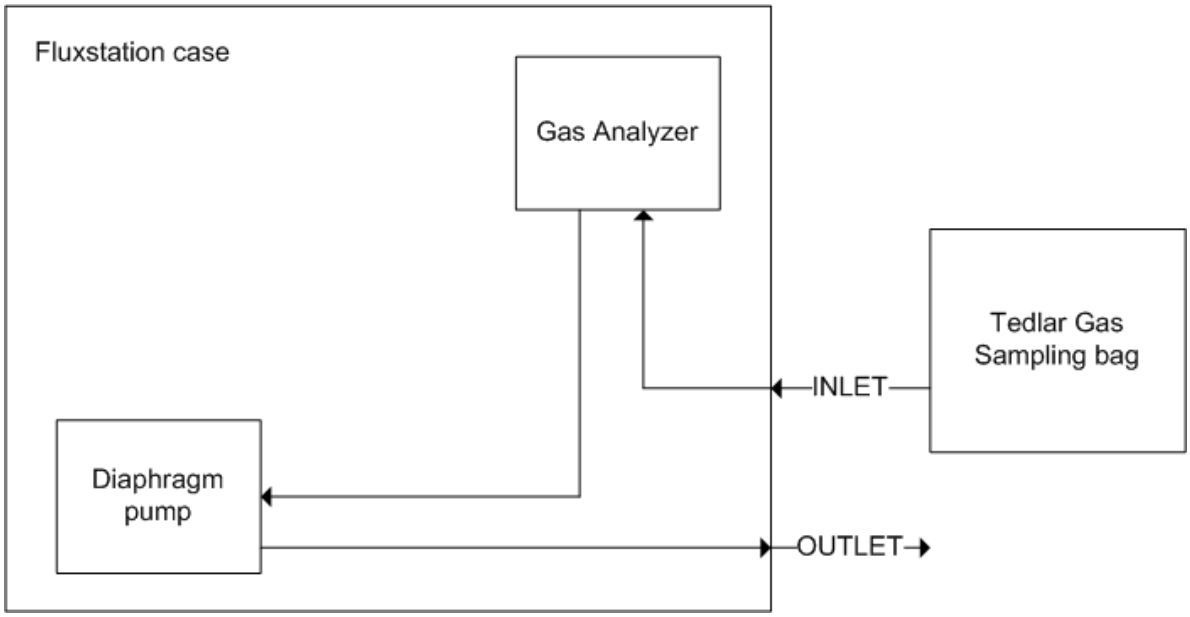
How to perform a calibration check

1- Before verifying the calibration, turn on the detectors (menu [MEASURE] [SHOW ANALOG VALUES]) and leave it on for a minimum of 5 minutes to warm up.

2- Start the pump from the menu [COMMANDS] [SET PUMP STATUS]

3- Fill the first Tedlar bag with nitrogen.

4- Connect the Tedlar bag to the inlet port of the flux station, as shown in the following diagram. In this way the pump will get the content of the bag into the detector and finally to exhaust passing from the outlet port.



5- Check the reading on the station display (menu [MEASURE] [SHOW ANALOG VALUES]). Wait for the value to stabilize and finally take note of the reading.

6- Disconnect the bag from the inlet.

7- Fill the second Tedlar bag with the CO_2 mixture.

8- Connect the Tedlar bag to the inlet port of the flux station.

9- Check the reading on the station display (menu [MEASURE] [SHOW ANALOG VALUES]). Wait for the value to stabilize and finally take note of the reading.

To simplify the explanation, please see the following example:

Let's suppose that the check performed gave the following results:
Injecting a mixture at zero concentration of carbon dioxide the CO2 detector returns a reading of 10 ppm.
Injecting a mixture containing a 10,000 ppm concentration of carbon dioxide the CO2 detector returns a reading of 9940 ppm.
At a variation of concentration set at 10,000 ppm the instrument has a slightly different response: 9930 ppm (=9940-10 ppm). The evaluation error is of about 70 ppm, which in percentage points over the span corresponds to 0.6% less.

The error in evaluating the increment in concentration manifests as a systematic error in the evaluation of flux and, therefore, must be corrected by calibrating the instruments when it is too high (> 5%).

If the calibration check results are not satisfactory, it's necessary to re-calibrate the detector.

What you need in order to calibrate the LI-COR LI-820

- A cylinder of nitrogen or CO_2-free mixture.
- A cylinder of standard mixture of a known concentration of carbon dioxide in air (or nitrogen) *;
- Two Tedlar gas sampling bags, of 5 or 10 liters capacity.
- A laptop with Microsoft Windows operating system, and a RS232 serial port (native or USB adapter).
- A Null-Modem serial cable (furnished).

How to perform a calibration

1- Switch on the LI-820 detector and wait for the sensor to warm up, until the cell temperature reaches about 51°C. You can check the value through the menu [MEASURE] [SHOW ANALOG VALUES]).
If the station is configured not to keep the LI-820 always ON, entering the menu [SHOW ANALOG VALUES] will wake up the LI-820.

2- Connect the LI-820 to the laptop and start the LI820 PC Software. Select the port and press *Connect*. The application will show CO2 real time data.

3- Select View, Calibration to open the calibration window. Connect the first sampling bag, previously filled with nitrogen, to the INLET of the station.

4- Start the station pump, menu [COMMANDS][2.4 SET PUMP STATUS]. The LI-820 start to analyse the bag content.

5- Wait for the CO2 reading to stabilize and press *Zero*.

6- Once finished, connect the second sampling bag, previously filled with CO2 mixture, to the INLET of the station.

7- Wait for the CO2 reading to stabilize; then input the ppm concentration of your calibration mixture (e.g. 15000) in the field *Span gas concentration*. Then press Span.

8- Once finished, check the CO2 reading of the two gas standards. Repeat calibration if necessary.

Refer to LI-820 manual (Chapter 3: Operation) for more detailed instructions.

10.2 Calibration of the flux meter

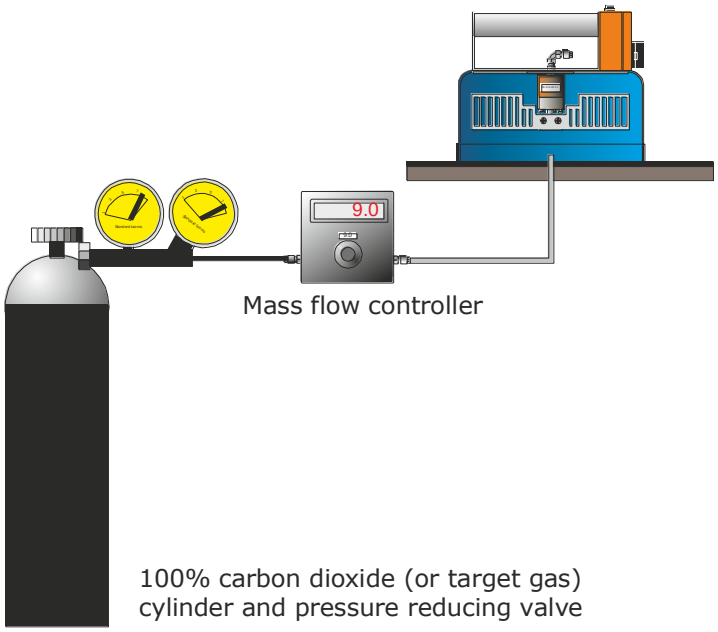
As the computation of flux is a function of the gradient of concentration vs. time, barometric pressure, air temperature and the accumulation chamber volume / surface ratio, the calibration of the instrument depends only on the detector

calibration. The accuracy of the barometric pressure and air temperature measurement affect the evaluation of flux: 3 degrees Celsius of error while evaluating the temperature will cause a 1 % of error when computing the flux. A 10 HPa (mBar) error measuring the barometric pressure will cause a 1% error in the flux evaluation.

How to verify the fluxmeter calibration

The calibration described refers to carbon dioxide calibration, for other gases, like methane or hydrogen sulphide, the same procedure has been followed.

Sketch of calibration device



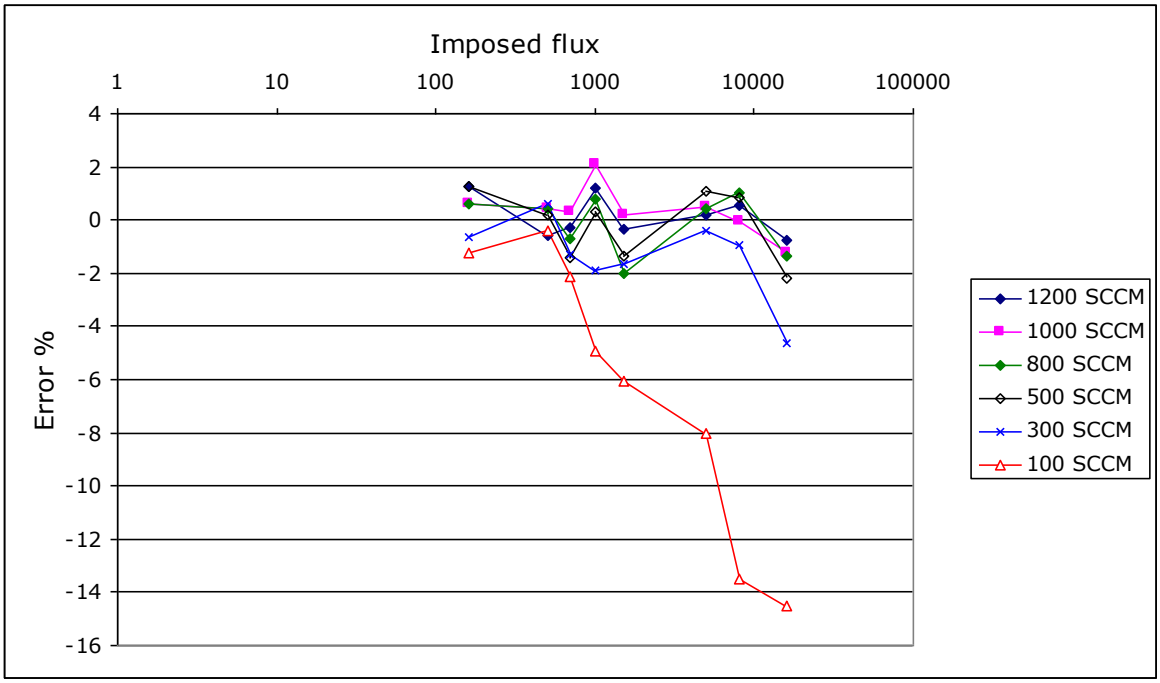
CO2 fluxes from soil are simulated by injecting a known flow of gas into the accumulation chamber. The interface between the accumulation chamber and the calibration table is built to minimize the gas leakage.
The apparatus is schematized in figure 1.
The injected flux is controlled and measured with a precision mass flow controller. This MFC, calibrated for CO2, is electronically stabilized, with accuracy: ± (0.8% of Reading + 0.2% of Full Scale).

A thermometer and barometer were utilized to measure the barometric pressure and the air temperature during the experiment in order to select the correct accumulation chamber conversion factor.
A flow meter is utilized to measure the pumping flow during the experiment.
During all the measures a 100% CO2 flow was utilized.
The same procedure was utilized to check the instrumental response to methane / Hydrogen Sulphide.

The influence of pumping flow

Influence of pumping efficiency on the flux measurement results:
We have carried out some sets of measures utilizing the same injected flux but with different pumping flow from the accumulation chamber to the detector.

The pumping flow was changed by means of a mechanical flow reducer and measured with a Microbridge Mass Airflow sensor (Accuracy 2%).
We have not noted a significant variation of the measures except when the pumping flow is less than 200 SCCM.



In the diagram the plot of the measurement error versus the imposed flux of carbon dioxide (expressed in grams per square meter per day) at different pumping flow rates is shown.

In order to avoid unwanted variation of pumping flow due to power supply the pump is supplied at 12 V DC with a stabilized voltage regulator.

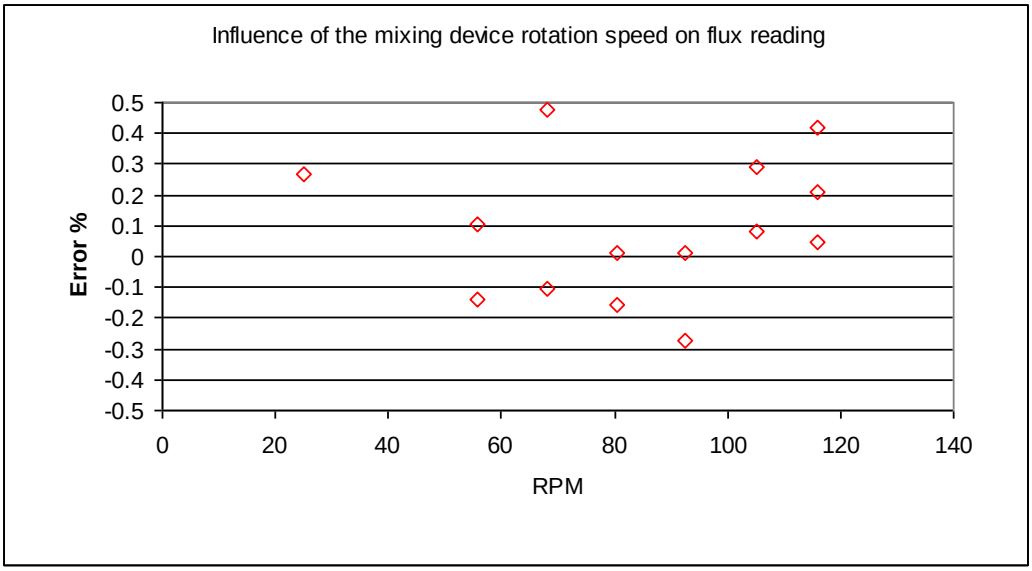
The pumping flow , after the power supply stabilization, is 1000 SCCM 20%. The efficiency of pump can vary due to dust or moisture in the pump body. Periodic maintenance is necessary.

The influence of mixing device

The mixing device was suspected, by some researcher, to affect the accuracy of the flux measurement.
In our experience the precision of the measurements was notably reduced without a mixing device present.
In the plot below the measurements at various regimes of mixing device rotation are reported.

Influence of the mixing device rotation speed

10 Calibration



11. Database Structure

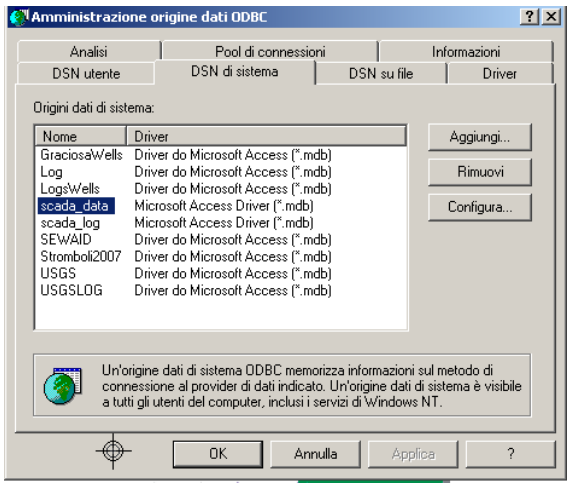
11.1 The databases

All the information necessary to run WS-Scada, as well as the data acquired by the fluxstation, are stored in the database *scada_data*.

A second database (*scada_log*) is used by WS-Scada to log messages, error reports and other information that are generated by WS-Scada and that can be helpful to diagnose some malfunctions of the system.

The two databases are accessed by our software via ODBC. For this reason, two DSN entries are stored in the ODBC manager of the operating system.

Both DSN are created automatically by the WS-Scada setup. Normally it's not necessary to modify it manually.



The four applications of WS-Scada suite read the system DSN from the ODBCName.txt file, located in the C:\WEST\scada\source\ folder.

The first line sets the DSN that point to the data and settings database and the second line sets the DSN that point to the log database.

Database *scada_log*

The database *scada_log* is composed by several tables:

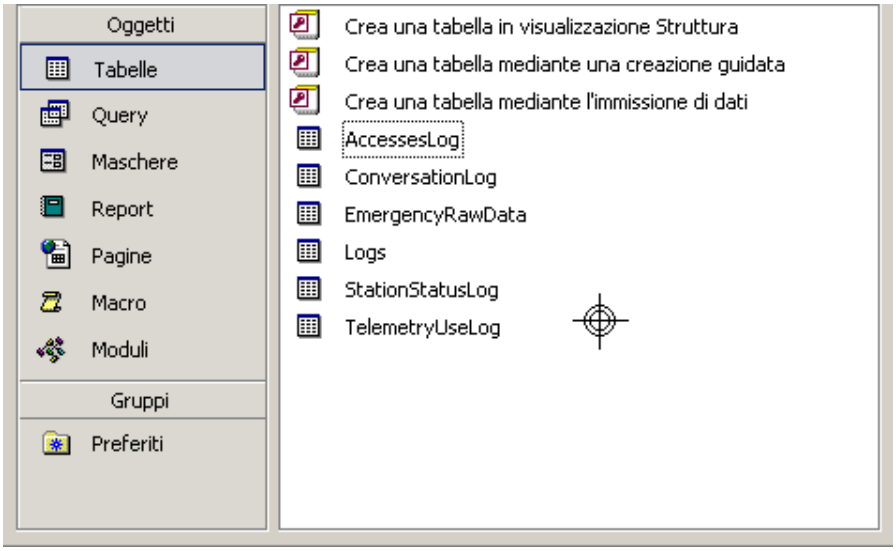
AccessesLog: Information about the WS-Scada instances that accesses the DB.

ConversationLog: Information about the human-readable communications between WS-Scada and the flux stations;

EmergencyRawData: Raw data coming from the flux stations: useful for malfunction diagnostic;

StationStatusLog: Information about the status of the flux stations;

TelemetryUseLog: information about the use of the telemetry system. Designed to check the bill, in case of GSM based telemetries.

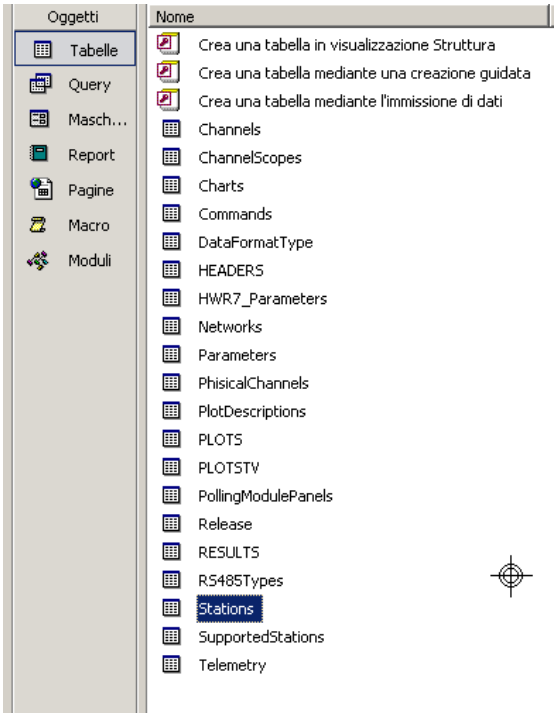


The information in scada_log is not useful during the "normal" operation of the system. Some of troubleshooting can be understood using its information.

Database *scada_data*

To understand the structure of the database is not important for the standard use of the system. This information is reported for documentation purpose.

scada_data is composed by several tables, some of them are to define the flux stations and their configuration. Some of them contain the results acquired by the flux stations.



The tables:
HEADERS
RESULTS
PLOTS
PLOTTV
contain the data generated by the fluxstations

The tables:
ChannelScopes
Commands
Parameters
DataFormatType
RS485Types
SupportedStations

contain the auxiliary data necessary for the correct working of the Scada software suite.

The tables:

Networks
Stations
Channels
PlotDescription
PhisicalChannels
Telemetry
HWR7_Parameters

contain the description of the monitoring network. The stations can be divided into Networks. Each WS-Scada instance can control one network.

Each FluxStation must be defined in the ***Stations*** table.

Field	***Value***	***Description***
ID	13	Record ID (Counter)
Active	-1	-1 = Active // 0 Not active
NetworkID	WS	Has to be **WS**
StationID	OVK01	Identifier of station
StationIP	0001	Address of station
Description	Flux Station 2007	
TelemetryID	SSR24	Type of telemetry
TelemetryName	2427581	* Address of remote telemetry system
TelemetryPath		* Optional repeater address
Site		Name of the site
Latitude		Localization of site
Longitude		Localization of site
Elevation		Localization of site
Responsible		Name of responsible
Type	HWR7	Station type
Model	1	Station subtype
PollingFrequency	24	** See note
PollingTimeShift	00.15.00	** See note
PollingRetryDelay	5	** See note

The **telemetryname** and **telemetrypath** formats and values are depending on the telemetry type (**TelemetryID**). If the station is connected with a serial cable (**TelemetryID = "COM_1"**), or with a point to point radio connection these to fields are not considered, simply because there is not necessity to address the communication. If your system has a SSR24 (SpreadSpectrum radio system) based telemetry, the field must contain the slave address.

PollingFrequency is the number of telemetry calls that Scada will perform during a day to download the flux station data.

PollingTimeShift is a delay, expressed in hh:mm:ss, that will be added to the time of telemetry call: If pollingfrequency is 24 Scada will execute a call every hour plus the PollingTimeShift time. Then Scada will call the station at 1:15, 2:15 , 3:15 and so on. The PollingShiftTime must be synchronized with the radio ON and radio OFF parameters of the flux station in order to call the station when the telemetry is ON (on battery-powered stations).

PollingRetryDelay, expressed in minutes, is used in case of fail if the communication. If Scada is not able to call the remote station it retries to call after PollingRetryDelay minutes. If PollingRetryDelay is set to zero Scada will retry to call the station only at the next scheduled time.

The Site, Latitude, Longitude, Elevation and Responsible fields contain only descriptive data.

Type and *Model* are critical parameters that indicate to Scada how to manage the station and must be not modified.

StationID is the station identifier and cannot to be modified. The *StationIP* is the logical address of the station and cannot to be modified.

11.2 Databases structure

Database *scada_data*
The *PhisicalChannels* table contain information about the "phisical" configuration of the station channels.

ID	StationID	Number	Name	FullScale	LowScale	Gain	Offset	Statistics	PlotCurve	Conf	Type
47	OVK01	0	CO2	20000	0	1	0	1	-1	FF06	ANALOG
48	OVK01	1	Bar.P	1060	600	1	0	1	0	FF05	ANALOG
49	OVK01	2	Ch.2	5000	0	1	0	1	0	FF06	ANALOG
50	OVK01	3	Ch.3	5000	0	1	0	1	0	FF05	ANALOG
51	OVK01	4	Ch.4	5000	0	1	0	1	0	FF05	ANALOG
52	OVK01	5	Ch.5	5000	0	1	0	1	0	FF05	ANALOG
53	OVK01	6	dP	1100	600	1	0	1	0	FF05	ANALOG
54	OVK01	7	P.Flow	1000	0	1	0	1	0	FF0F	ANALOG
55	OVK01	1	SOILBOX Soil W.	100	0	1	0	1	0	A0	DIGITAL
56	OVK01	2	SOILBOX Soil W. Raw	35	15	1	0	1	0	A1	DIGITAL
57	OVK01	3	SOILBOX Soil T.	200	0	1	0	1	0	22	DIGITAL
58	OVK01	4	SOILBOX Soil T. Raw	200	0	1	0	1	0	A2	DIGITAL
59	OVK01	169	AIRBOX Air RH	0	0	1	0	1	0	DA	DIGITAL
60	OVK01	170	AIRBOX Air T	0	0	1	0	1	0	D9	DIGITAL
61	OVK01	171	AIRBOX Wind Speed	0	0	1	0	1	0	D7	DIGITAL
62	OVK01	172	AIRBOX Wind Dir	0	0	1	0	1	0	D8	DIGITAL
63	OVK01	173	AIRBOX Rain Gauge	0	0	1	0	1	0	DF	DIGITAL

There are two basic type of "channel": ANALOG or DIGITAL; The 8 analog channels are managed by the AC board of the flux station. The digital channels are devices (AirBox and SoilBox in the base configuration) that are connected to the station with a serial connection (RS485).

ANALOG
Number is the phisical ADC ID;
Name is a short mnemonic description;
FullScale, **LowScale** and **Conf** are used to set the type of signal to be read (Voltage or Current) and the range of the detector connected to the channel;
Gain and **OffSet** can be used to scale the result of the measurement;
Statistics change the statistic treatment reserved to the channel;
PlotCurve: Setting to -1 this value force the flux station to acquire a Flux Curve of the signal coming from this detector.

DIGITAL
Number is the logical RS485 ID of the device;
Name is a short mnemonic description;
Conf is the type device connected;
FullScale and **LowScale** depends on Conf and must not modified.
Gain and **OffSet** must not modified.

Statistics change the statistic treatment reserved to the channel;
PlotCurve: Setting to -1 this value force the flux station to acquire a Flux Curve of the signal coming from this detector.

Information about how to change the configuration and to send it to the FluxStation are reported on Chapter 12.

Channels **table**

The *Channels* table is derived from the *PhisicalChannels* one, integrated with additional records and contain all the "definition" necessary to manage the several signals managed by the station.

Each record define a **channel** , for instance **Air temperature** or **CO2 Flux**.

Most of the field of the table must not be modified by the user and are not documented here.

PanelPage: set the Scada panel where the channel information is displayed;

RowOnPanel: set the row on the Scada panel where the information is displayed;

RevisionPriority: When using Query, the list of channels will be in descending order and only the channels with RevisionPriority > 0 will be visible;

Monitored: Monitor will show the channels with monitored <> 0, see chapter 12;

MonitoringGroup: see chapter 12;

AlarmType, **ActiveThresholds**, **UPAlarm**, **UPPrealarm**, **DnPrealarm**, **DnAlarm**: these fields are related with an "alarm" signal managed by Scada.exe: see chapter 10;

Gain, **OffSet**: by varying these fields it's possible to scale the result values of the channel, ask to West Systems;

Name, **Description**: The name and the description of the channels;

Active: If active = -1 the channel will be managed by Scada.exe. To exclude a channel set active=0;

The direct (manual) modification of the *Channels* table can be very critical. Ask support to West Systems before to make any modification.

Telemetry table

The *Channels* table is derived from the *PhisicalChannels* one, integrated with additional records and contain all the "definition" necessary to manage the several signals managed by the station.

There are 3 possible base types of telemetry (Field *BaseType*):

- **DISK**

The station has not a telemetry system and the data is transferred via SDmemory card. In the telemetry table we defined a telemetry of this base type:

TelemetryID = SD
WindowStart=00:00:00
WindowStop=23:59:59
CommPort= 0
HostID= <blank>
Settings=<blank>
TelemetryType=DISK
BaseType=DISK
CommTimeOut=<blank>

If you want to set this telemetry for your station you've to put the ***Stations.TelemetryID = SD*** in the record of the *Stations* table that define your station.

- **ETH**

The station telemetry system is based on a
ethernet to serial converter (as the Moxa DE211)..

TelemetryID = Moxa_1
WindowStart=00:00:00
WindowStop=23:59:59
CommPort= Socket port of the IP.
HostID= IP address of the Moxa
Settings= RS232 parameters of the RS232 port of the moxa;
TelemetryType=MOXA
BaseType=ETH
CommTimeOut=2000

If you want to set this telemetry for your station you've to put the ***Stations.TelemetryID = Moxa_1*** in the record of the Stations table that define your station.

- **RS232**

The base type RS232 supports several TelemetryTypes:

GSM: Gsm based data modems;

SSR24: Spread spectrum 2.4 or 0.9 GHz in switched mode;

RS232: Direct cable connection.

The base type RS232 supports several TelemetryTypes:

The configuration of each type is described in the telemetry handbook.

SSR24 : Appendix F;
GSM : Appendix G; (not included)
RS232 : Appendix M;

General settings:
WindowStart, **WindowStop**: are used to define an activity time window for the telemetry: If Scada.exe has to share the telemetry with another application is possible to define a time window, for instance between 11:00:00 and 16:00:00.
Scada.exe will use the telemetry system only during this interval.

CommTimeOut: Is a TimeOut interval, expressed in milliSeconds. The communications can suffer of latency times (as for example a Moxa device connected via a IEEE802.xx network, or via an ADSL connection). By setting a proper value to CommTimeOut can solve the problems due to long latency times.

11 Database structure

12. WS-Scada software suite

12.1 Software installation

The Scada software runs on Microsoft Windows operating system (XP, Vista, 7, 8, 10). Microsoft .NET Framework is required.

WS-Scada Software Suite is compatible with the following DBMS:

- MYSQL (default)
- PostgreSQL
- Microsoft SQL Server
- Microsoft Access

In this chapter the MYSQL and Microsoft Access installations will be described.

10.1.1 MYSQL based Installation

This manual assumes the following prerequisites:

- On the Windows machine on which you're going to install the Scada Suite, the MYSQL ODBC Connector must be installed. If it isn't, the installer it is furnished with the West Systems installation CD or it can be downloaded from MySql website.
- The machined has access to a MYSQL server instance (version 5 or later), already active on the local machine or in remote. Otherwise, a MYSQL server version is also furnished in the West Systems installation CD.

Examples of the commands to be executed (and the corresponding responses by the server) will be shown in red.

1 – Launch the West Systems Scada setup application. The installer will extract the applications file in C:\WEST\Scada\source and the database dump files (C:\WEST\Scada\scada_data.sql and C:\WEST\Scada\scada_log.sql) which you'll need in the next steps.

2 - Create user and schemas

2.1 - Open a Windows console (press Start, then Run and digit cmd). Log in to the MYSQL server as super-user. Replace in the following examples the IP address 127.0.0.1 with the IP address of the machine where your MySql server is active, or leave it if the server is local. Replace also root and password with your credentials. Example:

```
mysql -h 127.0.0.1 -u root -ppassword

Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 636577
Server version: 5.0.45 Source distribution
Type 'help;' or '\h' for help. Type '\c' to clear the buffer.
mysql>
```

2.2 - Once authenticated, create the 2 schemas scada_data and scada_log.

```
mysql> create database scada_data;
Query OK, 1 row affected (0.04 sec)

mysql> create database scada_log;
Query OK, 1 row affected (0.04 sec)
```

2.3 - Create a user for the access to the database scada_data you've just created. The example shows how to create the user "scada_admin" setting the password "scada_admin", to be replaced with a more secure password.

```
mysql> grant all privileges on scada_data.* to scada_admin identified by
'scada_admin';
Query OK, 0 rows affected (0.10 sec)
```

2.4 - Grant privileges to the other database (scada_log) to the same user scada_admin.

```
mysql> grant all privileges on scada_log.* to scada_admin;
Query OK, 0 rows affected (0.10 sec)
```

2.5 - Finally, execute a flush to allow the settings to take effect immediately.

```
mysql> flush privileges;
Query OK, 0 rows affected (0.07 sec)
```

2.6 - Log out

```
mysql> exit
Bye
```

3 - Database import

At this point, we have two empty databases. To populate them with tables and data it's necessary to import the structures using the dump files furnished by West Systems. In the following example the 2 sql files has been previously copied to C:\scada_data.sql and C:\scada_log.sql.

3.1 - Access to the console and digit:

```
mysql –h 127.0.0.1 –u scada_admin –pscada_admin scada_data <
c:\scada_data.sql
```

At this point the import process will start. It could take several minutes. Wait until the command execution is completed.

3.2 - Import the structure of the second database:

```
mysql –h 127.0.0.1 –u scada_admin –pscada_admin scada_log <
c:\scada_log.sql
```

4 - Create ODBC connections

Once the databases are created, you need to make them accessible to the software suite. The software accesses the database using the ODBC layer (Open Database Connectivity).

4.1 - On the Windows machine where the application WS-Scada will be running, you need to install the MYSQL ODBC Connector, if not already installed. Execute the setup file mysql-connector-odbc-5.1.8-win32.msi.

4.2 - Once the Connector installation is completed, open the Windows Control Panel (Start – Setttings – Control panel). Open Administrative Tools, then Data Sources (ODBC).

4.3 - Move to the System DNS tab and press Add. Select MySQL ODBC 5.1 Driver and press Finish. The MySQL Connector/ODBC panel will show.

4.4 - Fill the fields as illustrated and press OK

Data Source Name:	scada_data
Description:	West Systems Scada database (data)
Server:	127.0.0.1 (replace with your MYSQL server IP)
Port:	3306 (replace with your MYSQL server port)
User:	scada_admin
Password:	scada_admin (replace with the password you have inserted at point 2.3)
Database:	scada_data

4.5 - Repeat steps 4.3 and 4.4 for the second database using the following settings:

Data Source Name:	scada_log
Description:	West Systems Scada database (log)
Server:	127.0.0.1 (replace with your MYSQL server IP)
Port:	3306 (replace with your MYSQL server port)
User:	scada_admin
Password:	scada_admin (replace with the password you have inserted at point 2.3)
Database:	scada_log

The databases are ready. You can launch now WS-Scada.

Note: How to execute a database dump
A dump exports into a single sql file both the structures of the tables and the data of a database. A dump can be used for several purposes:

- Make a backup of the database
- Export the data to be archived or sent to someone.

Open a console and digit:

```
mysqldump -h 127.0.0.1 -u scada_admin -pscada_admin scada_data >
c:\dump_scada_data.sql
mysqldump -h 127.0.0.1 -u scada_admin -pscada_admin scada_log >
c:\dump_scada_log.sql
```

12.2 General description

The software suite of Scada is composed by 4 applications:

WS-Scada: This application, designed to run continuously, performs the polling of the stations in your network, downloads and stores the data in a database and allow you to configure and manage the remote stations using a telemetry system.
Scada reads the network configuration from the scada_data ODBC data souce name (Chapter 9). Once reads the configuration it runs continuously to manage the information of all the stations that compose your network.

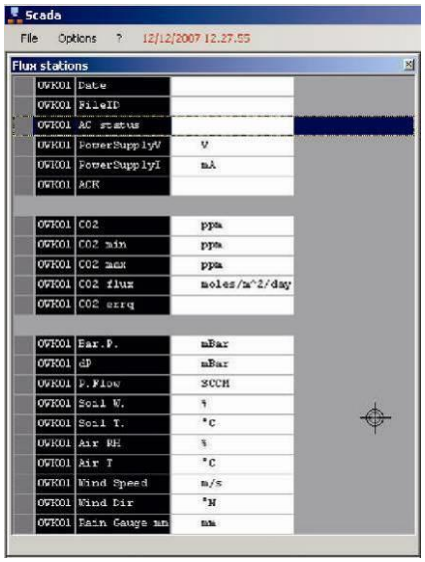
DataRevision: This application allows you to review the curves acquired by the stations.

Monitor: This application displays graphical charts of the last days of data.

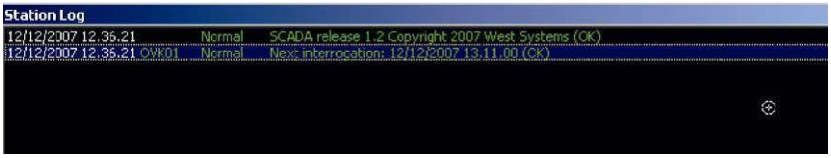
Query: This application allows you to query the database and obtain a table in the .xls or .csv format of the data stored in the database.

12.3 WS-Scada

Scada Panel
The Panel form resumes all the information of the station and its channels;
In the first column is reported the name of the station (Stations.StationID).
In the second column, the name of each channel (Channels.Name) and in the third column the result (empty in the example) of the last downloaded measurement and the unit.



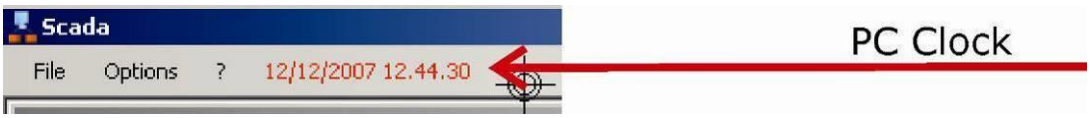
Station Log dialog box



The dialog "Station log" reports all the events related with the management of station and telemetries. This information is saved in the ***Conversation*** table of the **scada_log** database.
Normal events are reported in green, **Warnings** are reported in yellow and **Alarms** and **Errors** are reported in red.
In the drawing, after the Copyright message, a Normal event is reported:

The next interrogation of the OVK01 station is scheduled at 13:11:00 of 12/12/2007.

The log can be saved as text file by right clicking the text box and selecting {Save as}.



On the left-top corner of WS-Scada, the pc clock is shown: WS-Scada will use this date/time information to set the clock of each station, every time it will be able to communicate with the station. We suggest setting up a NTP service on the PC where WS-Scada runs, to make sure the station clock is always synchronized.

Also we suggest disabling the daylight saving time in the Windows PC. Keeping the automatic daylight saving time will result in the loss of one hour of data at each switch (twice per year).

After each interrogation, WS-Scada updates the channels panel with the last recorded data.

The general panel contains the following information:

- **Time last measure**: the date and time of the last analysis
- **Last sampled AC**: the number of the last sampled accumulation chamber, from 1 to 16
- **Main battery**: station power supply input voltage (battery or 12 V power supply).
- **Time next measure**: the date and time of the next scheduled analysis.
- **Next AC**: the number of the next accumulation chamber to be samples, from 1 to 16

If a weather station is present, the general panel will contain also:

- **BarP**: barometric pressure, expressed in [mBar]
- **AirT**: air temperature, expressed in [°C]
- **AirRH**: air relative humidity, expressed in [%]
- **Wind Speed**: wind speed, expressed in [m/s]
- **Wind Dir**: wind direction, expressed in [°N]. 0 is wind coming from North, 180 is wind coming from South.
- **Rain**: rain fall, expressed in [mm]

For each accumulation, a panel is present with the following information:

- **Date**: the date and time of the last analysis
- **AC Status**: status of the accumulation chamber. The status is codified as following:

OK: the station managed to close and open the chamber correctly.

NFC (Not Fully Closed): the chamber couldn't close perfectly: The lower proximity sensor didn't turn on at the end of the Chamber Down run. A possible cause is that an obstacle is preventing the chamber to close. If the flux curve shows a good accumulation, then it's more likely than the proximity sensor is not well placed.

NFO (Not Fully Opened): the chamber couldn't open perfectly: The upper proximity sensor didn't turn on at the end of the Chamber Up run.
In this case check the proximity sensor is not well placed or if there is an external cause. Note that when the battery voltage is very low (under 11.5 V) the run will be slower so it can happen that the chamber cannot fully open within the maximum time.

NFC-NFO: we have both NFC and NFO situation.

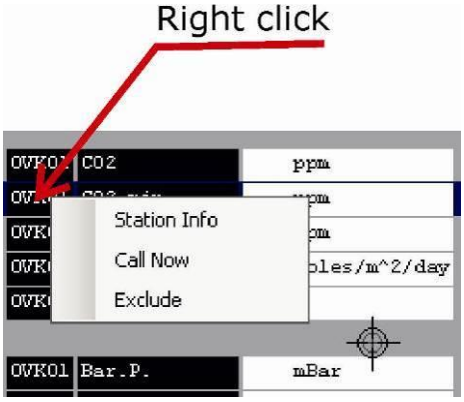
ERR: the chamber is not connected or did not respond correctly.

MUX-ERR: the multiplexer is not connected or did not respond correctly.

Note: Exporting the data into Excel or CSV files using the Query software, the AC status is presented under numeric form following codification:
0: OK
1: NFC
2: NFO
3: NFC-NFO
4: ERR
5: MUX-ERR

- **Pump flow**: the flow rate of the pump.
- **CO2 Flux**: carbon dioxide flux rate, expressed in [moles/m^2/day]
- **CO2 Errq**: carbon dioxide linear regression coefficient of determination, from 0 to 1.
- …
- [Flux repeated for each monitored gas species]
- [Errq repeated for each monitored gas species]
- …
- **Soil VWC**: volumetric water content of the soil, measured by the CS616 probe.
- **Soil Temp**: temperature of the soil, measured by the PT100 probe.
- **Pressure**: pressure measured inside the chamber, expressed in [mBar]
- **Air Temp**: air temperature measured inside the chamber, expressed in [°C]
- **Battery**: voltage of the chamber buffer battery.

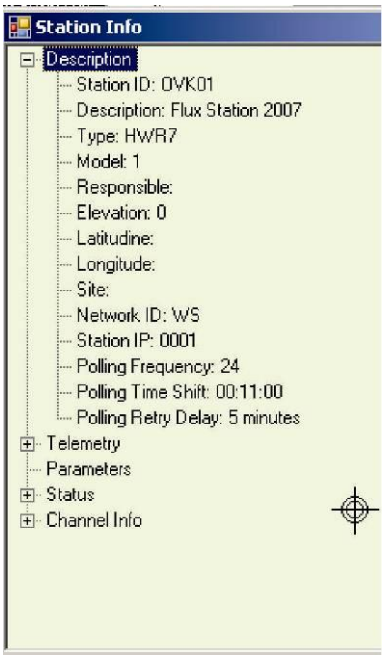
Note: the general panel us updated after each WS-Scada interrogation.
On the contrary, only the panel relative to the sampled chamber will be updated. The other panels will remain unchanged until the relative analysis file is downloaded.



By right clicking on the StationID field of a station a menu appears.

Station Info

By selecting *StationInfo* you can get a report where all the information about the station, the telemetry , the configuration parameters, the status and about all the channels that belong to the station are present. The StationInfo report will be automatically closed after 30 seconds.

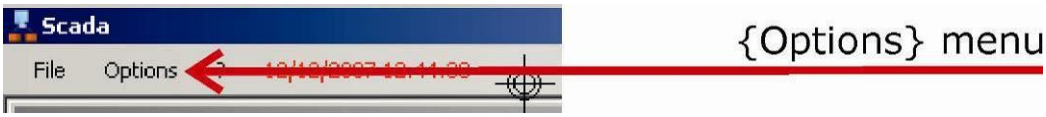


Exclude

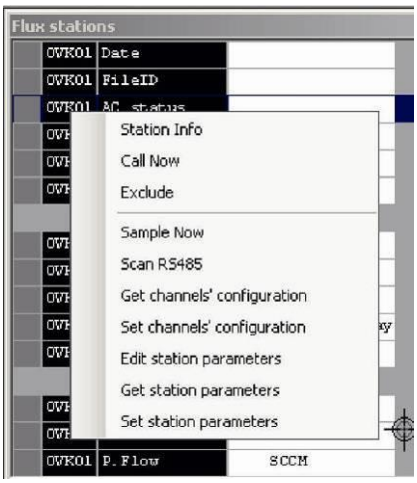
By selecting *Exclude* you can temporary exclude the station. While excluded a station is not managed by the application. This feature is normally used when a station is under maintenance to avoid useless telemetry calls. While excluded the background colour of the station will be red. To reactivate the station, select *Include* from the same menu.

Call Now

By selecting *Call Now* the application re-schedule the next call to now. Of course, you've to consider that the remote telemetry system can be off and then the call will be not successful.



By selecting *Options*/*Show advanced menu,* an advanced station menu will be enabled, then now right clicking the StationID field a more complete menu is shown.



Sample Now
By selecting *Sample Now* you force the immediate execution of an analysis cycle. The command will be sent to the station during the next call, then to have an immediate effect {Sample Now} must be followed by {Call Now}.

Get channels configuration
By selecting *Get channels configuration* the application will download the configuration of the channels from the station and will store this configuration in the database. The action will be performed during the next scheduled call.

Set channels configuration
By selecting *Set channels configuration* the application will upload the configuration of the channels from the database to the station, reconfiguring the station with the database settings. The action will be performed during the next scheduled call.

Get station parameters
By selecting *Get station parameters* the application will download the timing parameters of from the station and will store it in the database. The action will be performed during the next scheduled call.

Set station parameters
By selecting *Set station parameters* the application will upload the timing parameters from the database to the station and will re-configure the timings of the analysis cycle. The action will be performed during the next scheduled call.

Edit station parameters
By selecting *Edit station parameters* the application allows you to modify the timings of the analysis cycle (parameters) and to save it in the database.

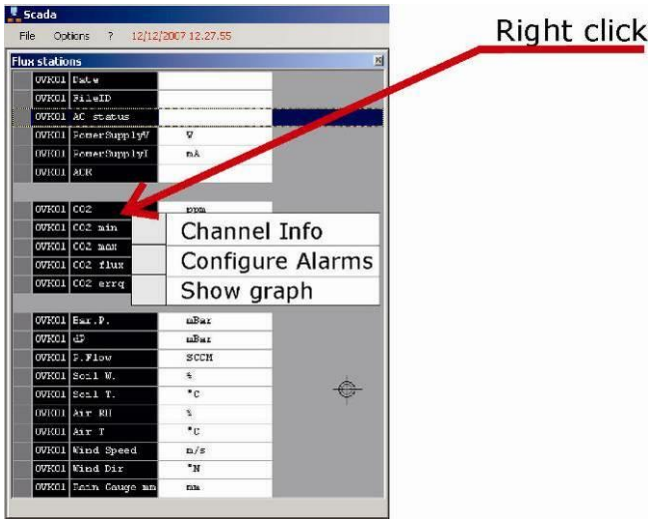
Since all the actions described in this page, except *Sample Now*, are quite critical we advise you to follow this procedure:

a) Do NOT get or set the channels configuration unless big malfunction of the system. Anyway, before to do that, please contact West Systems support.

b) To change the parameters:

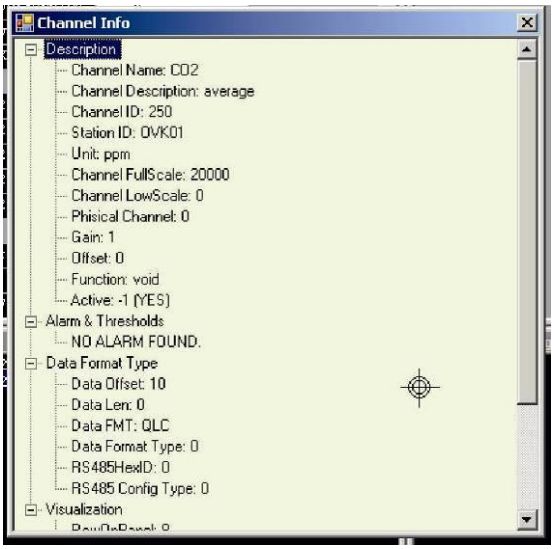
1) select *Get Station Parameters*; wait the next successful call;
2) Edit the parameters *Edit station parameters* and save into the database;
3) select *Set Station Parameters*; wait the next successful call;

Now the station is set with new parameters



By right clicking on the Channel.Name field of a station a menu appears.

Channel Info
By selecting *Channel Info* a report of the channel configuration and status will be shown.

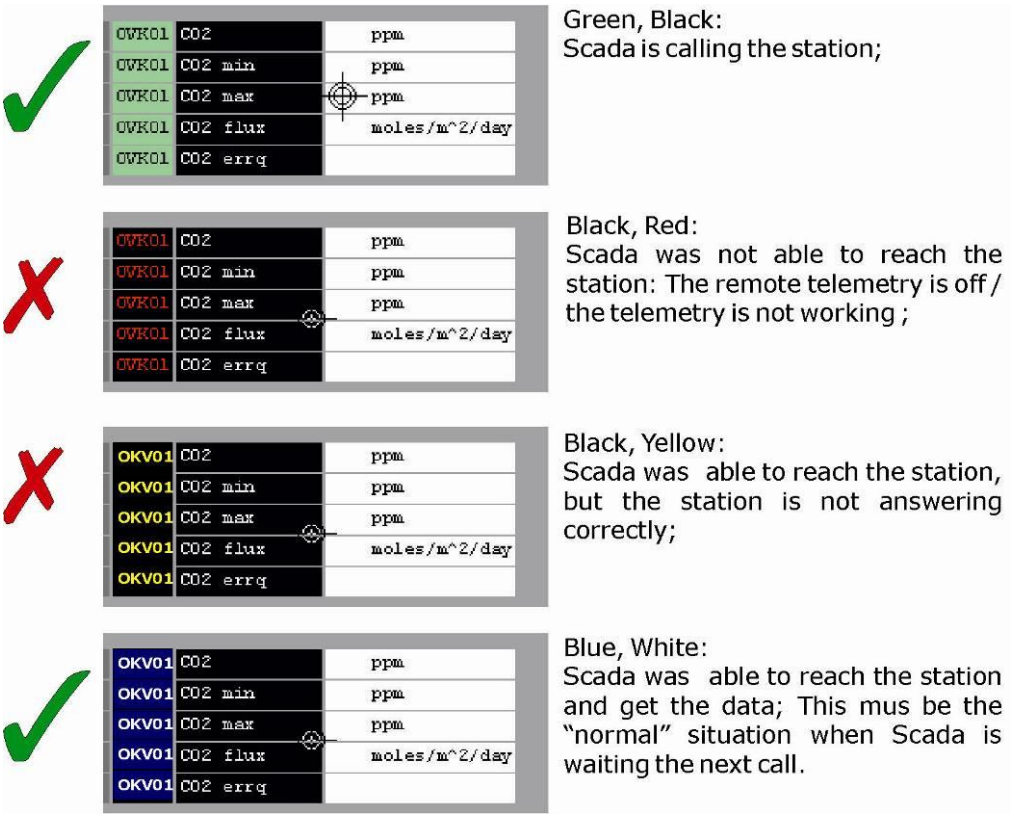


Configure Alarms
By selecting *Configure Alarms* will be possible to set alarm level and modalities for the channel.
All thresholds / only upper thresholds / only lower thresholds / Alarm not active;

Show graph

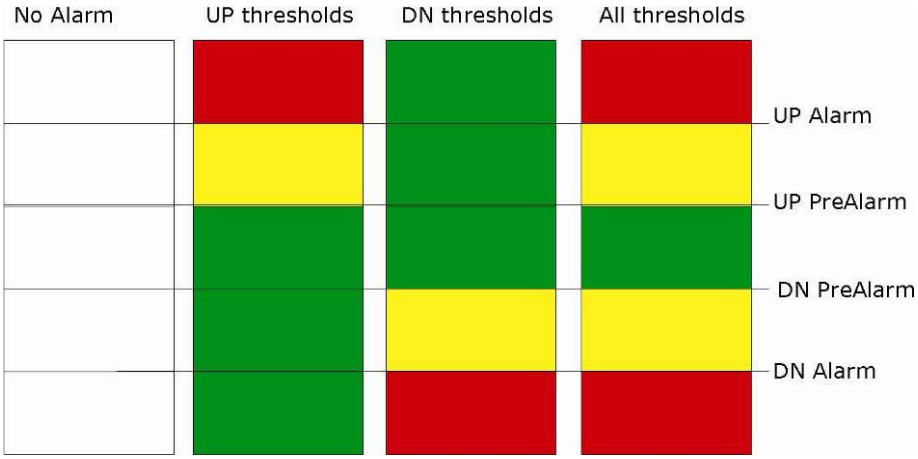
By selecting {Show Graph}, active only for the channels that are configured to be acquired as curve, the last downloaded curve will be displayed.

The StationID field backdoor and forecolour change in function of the status of the call.

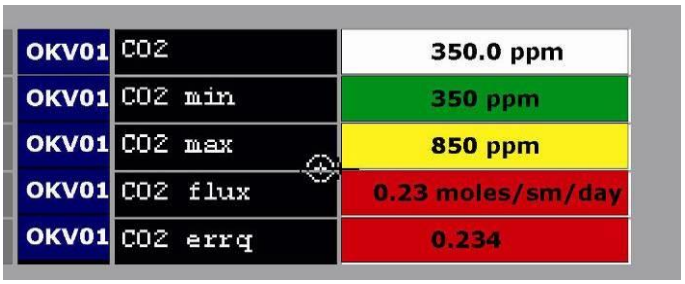


12.4 The alarms

For each channel is possible to set an alarm:



The alarm management will modify the backdoor of the result field of the channel in order to highlight when a value is not "correct"



The channel result field backcolor can be:

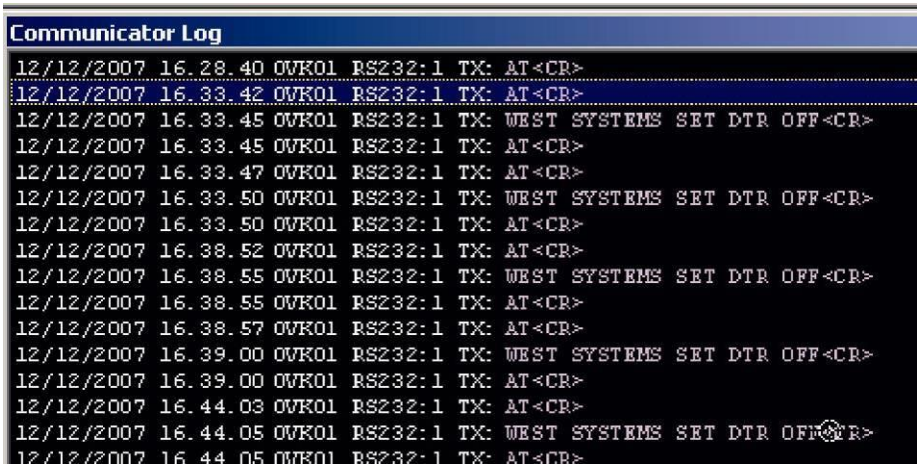
WHITE: if the channel has not alarms configurated. All the values are considered OK;

GREEN: The channel has alarms configurated and the value is in the normal range;

YELLOW: The channel value is between the pre-alarm and alarm thresholds;

RED: The channel value higher than the UPalarm threshold (Or is less than the DNAlarm one);

In the lower right corner a dialog shows the "binary" communication that flows on the communication stream between computer and telemetry device:



Some of the byte are "translated" in a visible format: for example the byte &0D (That correspond to the Enter key) is displayed as <CR>.

The format is:

dd/mm/yyyy hh:mm:ss : 12/12/2007 16.28.40
stationID : OVK01
Telemetry Type : RS232
Communication port: 1
Direction of communication: TX (or RX)
Transmitted data: AT<CR>

The communication log can be saved on a text file by right clicking on the text box and selecting *Save as*.

12.5 How to download data without telemetry

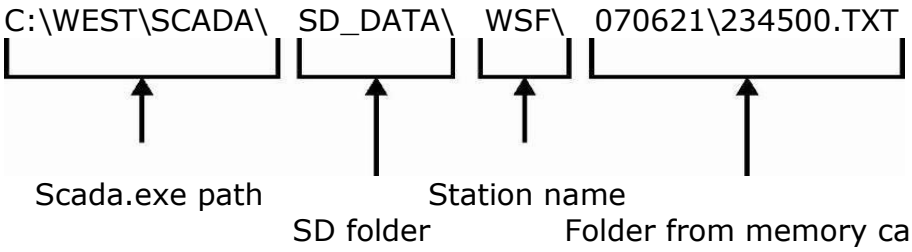
In case of a telemetry fault, it could be useful to download the data manually taking the SD card from the station and copying the files into the personal computer where WS-Scada is running.

Extract the memory card

You should avoid extracting the memory card while the "CPU RUN" LED is green still, in order not to risk losing any data: this is a warning that the station is going to access the card. The station turns on the "CPU RUN" LED 60 seconds before writing the measure file (usually every hour). Any other moment (LED off or blinking) is useful to safely extract and replace the card.

Copy the data to the PC

The station produces and writes to the memory card one folder per day. The folder is named according to the format YYMMDD (year, month, day): for example "070621" is referred to the 21th of June, 2007. In the folder are placed the analysis files named according to the format HHMMSS, for example "182900.txt" means that the file has been written at 6.29 PM. With the default configuration, a folder can contain a maximum of 96 files, one every 15 minutes.
WS-Scada supports both remote and local download of the data. In this case we'll use the local one, because the files are manually transferred to the PC.
You have to place the folders copied from the SD card into the directory C:\WEST\Scada\SD_DATA\STATION_NAME
This is an example of a probable complete path:

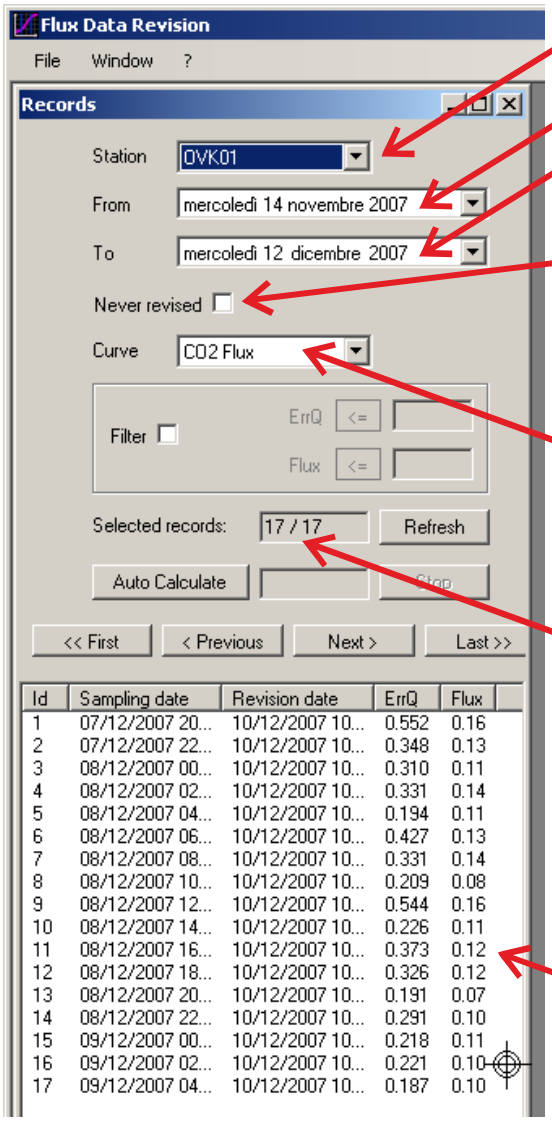


Import the files

When the station is called, WS-Scada scans its "SD_DATA" directory before accessing the telemetry, and imports the analysis file in the database. When a file is successfully read and saved to the database, WS-Scada automatically deletes it.

12.6 Data revision

DataRevision allows analysing the plots acquired by the station.



Select your station.

Select the initial date of the period.

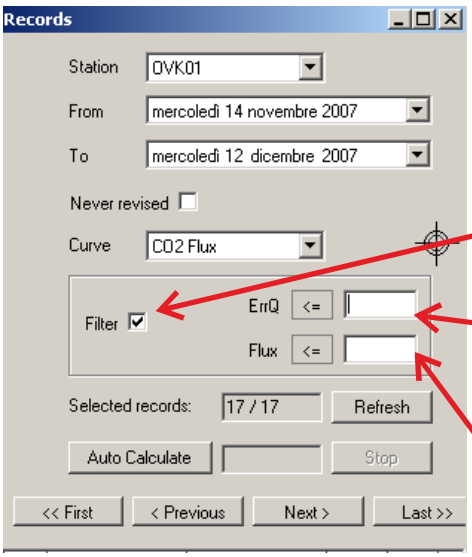
Select the end date of the period.

By selecting "Never revised" you can select the curves you never checked

Select the gas specie (If the station has additional gas detectors)

Number of selected curves / Total number of curves in the query period.

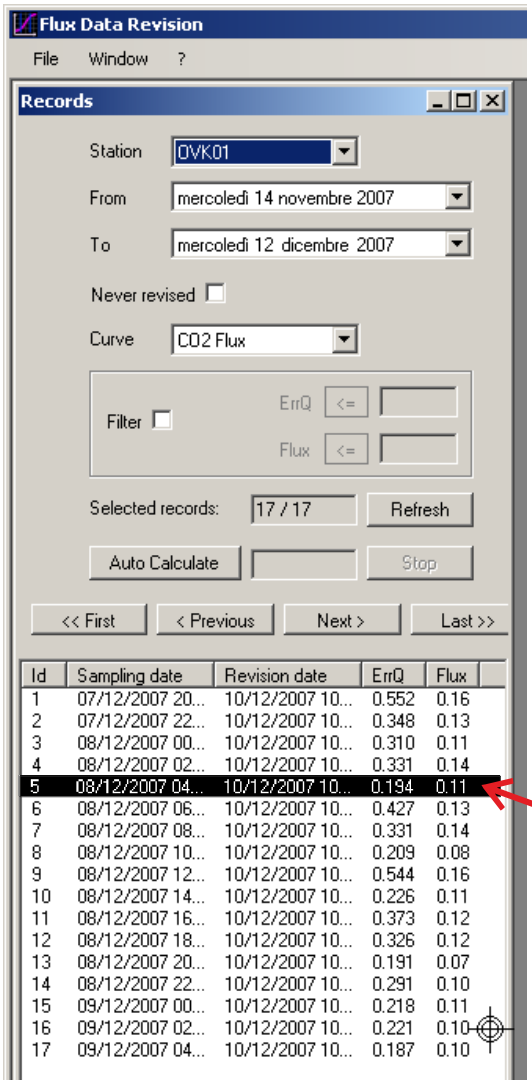
The list of flux curves that correspond to your selection



By selecting [Filter] you can apply a more restrictive filter to your query.

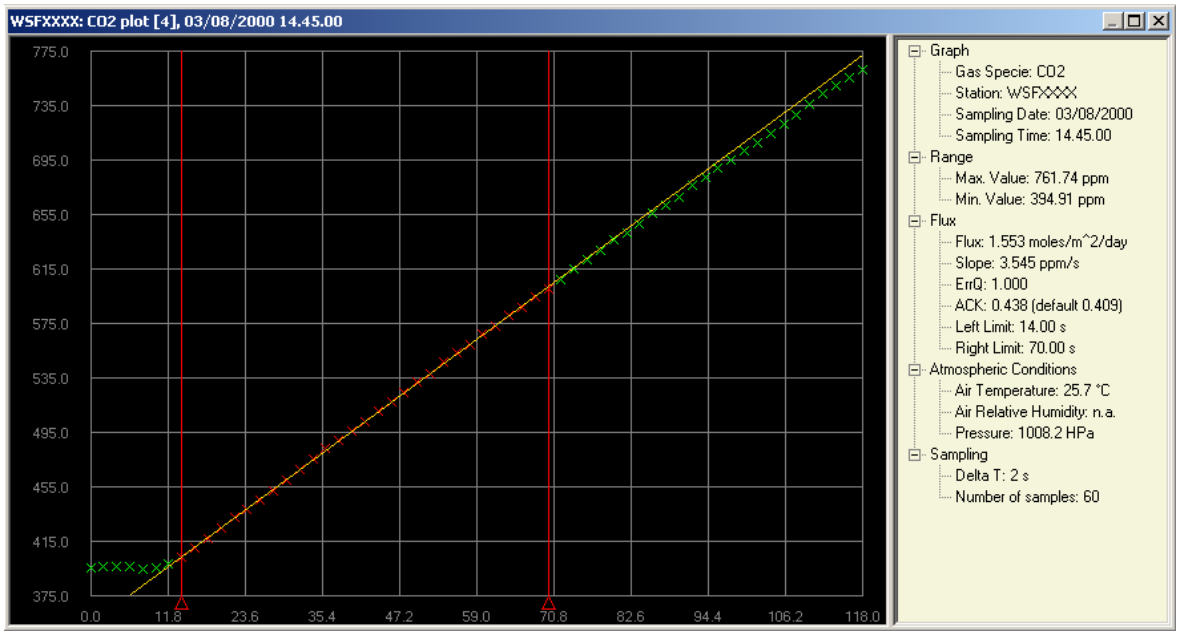
ErrQ <= 0.9 will select the curves where ErrQ is less than 0.9 (That means not very well shaped curves).

Flux >= 1500 Moles/sm/day will select the curves where the flux is more than 1500 moles/sm/day (That means exceptionally high flux).



To see the flux curve click on the list.

The flux curve



On the right part of the form is reported the information related with the flux curve.

The interval used to compute the regression is highlighted in red.

The regression computed is drawn in yellow.

The limit of the interval are the two red vertical lines.

The left and right limits are automatically selected by Scada when downloading of the data. Scada tries to pick the right fit using the DataRevision parameters. To modify the settings open the menu [File] [Settings].

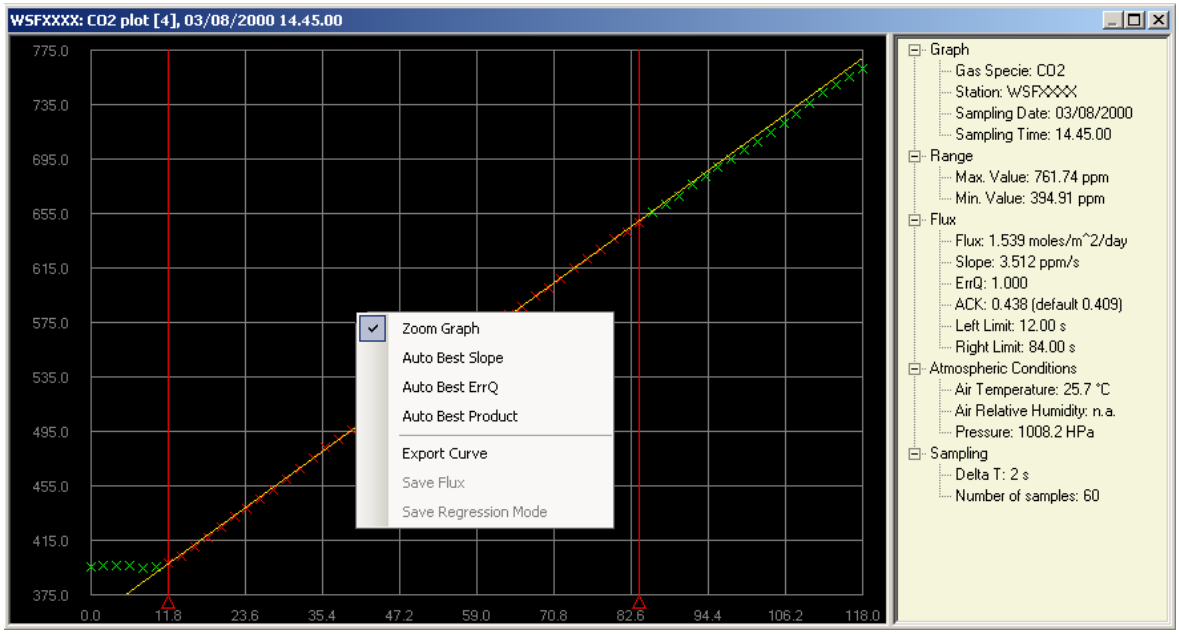
The settings are individual for every gas specie and accumulation chamber, because different gas detectors, as well as different accumulation chamber tube lenghts, can produce different response time.

See *Batch Processing* paragraph in the next pages for further detail.

Manual revision
Modify the limits by dragging the vertical lines in the desired position.

The flux, the slope and the ErrQ will be automatically updated.

To save the new result right click and select *Save Flux*.



Using the manual revision, the computation of flux is completely under your responsibility. You can select wrong interval and get wrong results, as in the drawing.

The slope of the curve is positive, but the selected interval, too short, gives a negative result.

Automatic computation of flux
DataRevision can compute the flux following 3 different algorithms:

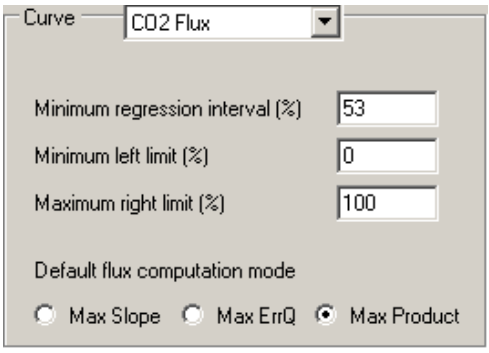
By selecting {Auto Best slope}: the flux will be computed searching for the higher flux;
By selecting {Auto Best ErrQ}: the flux will be computed searching for the better regression quality;
By selecting {Auto Best Product}: the flux will be computed searching for a compromise between higher flux and best regression quality.

The automatic computation uses, as minimum interval to be used, the interval selected by left and right limits (The two red vertical lines), then if you want to compute the flux using at least 50% of the points in the curve you've to select approximately the 50% of the curve and after select one of the 3 methods for the auto computation. After that you've to select {Save regression mode} to save this setting.

The saved settings will be used by the batch processing of DataRevision and by WS-Scada, when it processes the curves while downloading for the station.

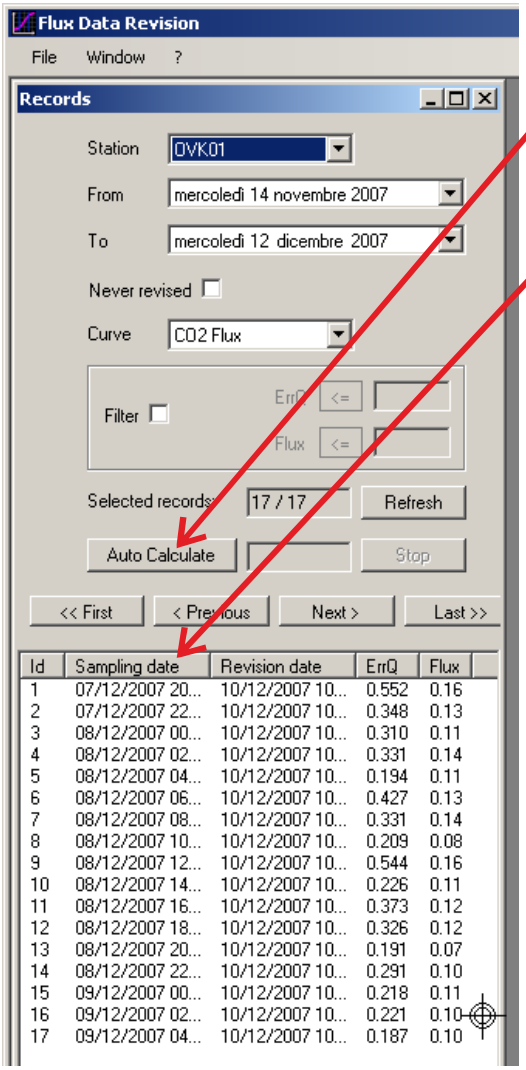
Batch processing
By pressing the [Auto Calculate] button DataRevision will process all the flux curves in the list. The method and the minimum interval will be the one selected with the procedure described before.

More restrictive settings to the automatic processing can be set by opening the {File}{Settings} menu.



For each gas species, you can set the minimum interval, the minimum left limit and the maximum right limit, as well as the processing algorithm.
If you need a rigid processing, you can set rigid parameters as:

Interval: 80%
Minimum left: 10%
Maximum right:10%
With these settings WS-Scada and DataRevision are obliged to compute the flux in the range from 10% to 90% of the curve.



Batch processing

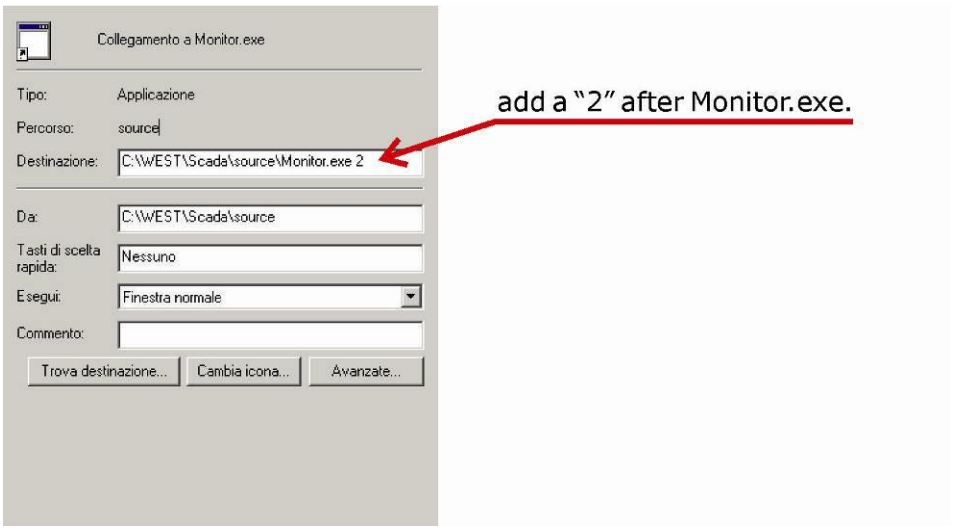
By clicking on [Sampling Date] you can order the list by date in ascending or descending mode .

same consideration for the Revision date, the ErrQ and the Flux.

12.7 Monitor

Monitor is a simple application designed to have a quick view of the last days of data (typically last week or last month).
Monitor displays the data of the channels that are active and having the field Channels.Monitored > 0 and the Channels.MonitoringGroup = 1;
The field Channels.MonitoringGroup can be used to assign a group of channels to a specific instance of Monitor.
To have two instances of Monitor, one showing a group of channels and the second showing a second group of channels you've to:

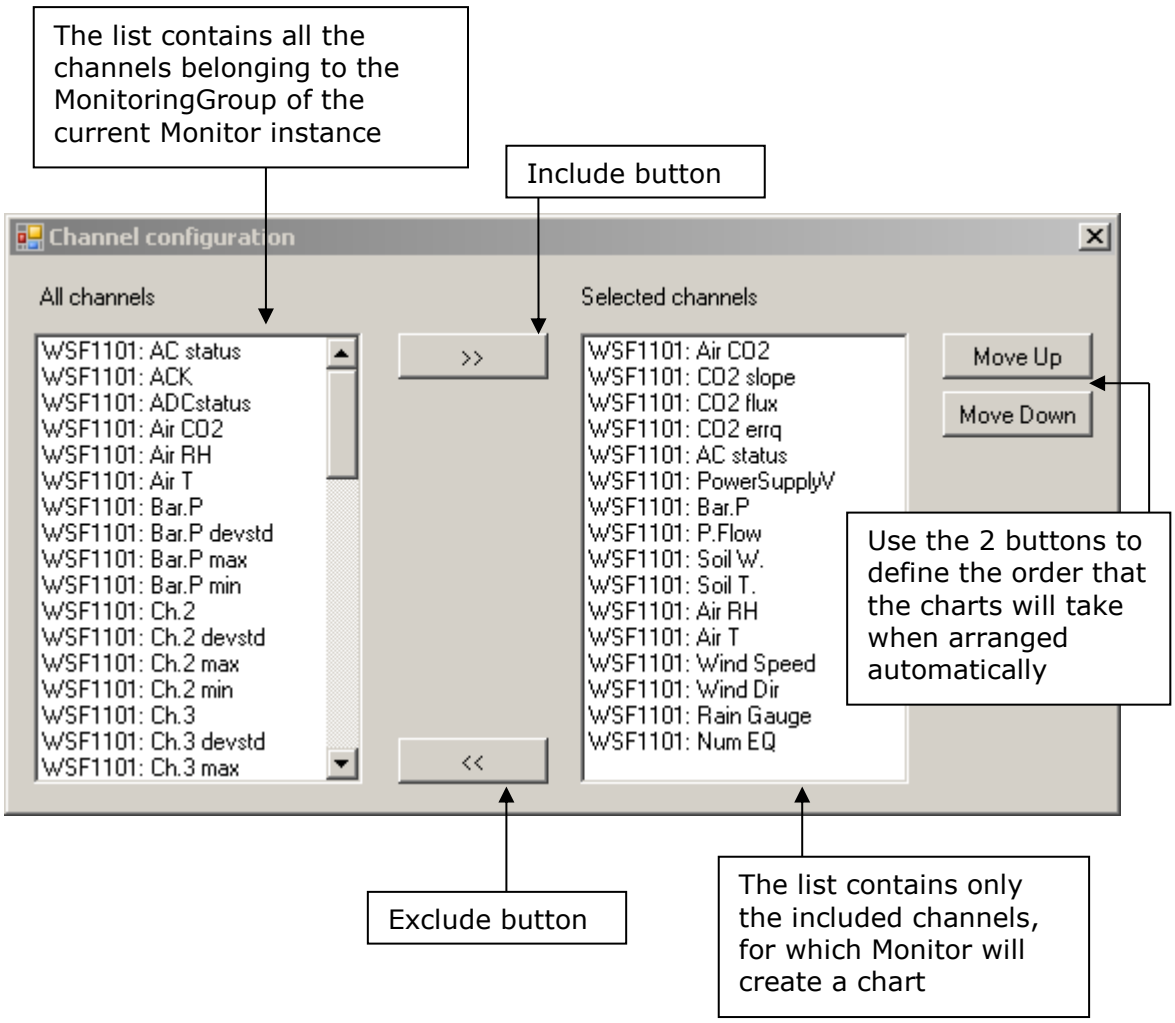
1) Open the Channels table of the database, put the value 2 on the Channels.MonitoringGroup of the channels you want to assign to the second group.
2) Create a new ShortCut of Monitor and modify the properties of the shortcut as following:



12.7.1 Channels

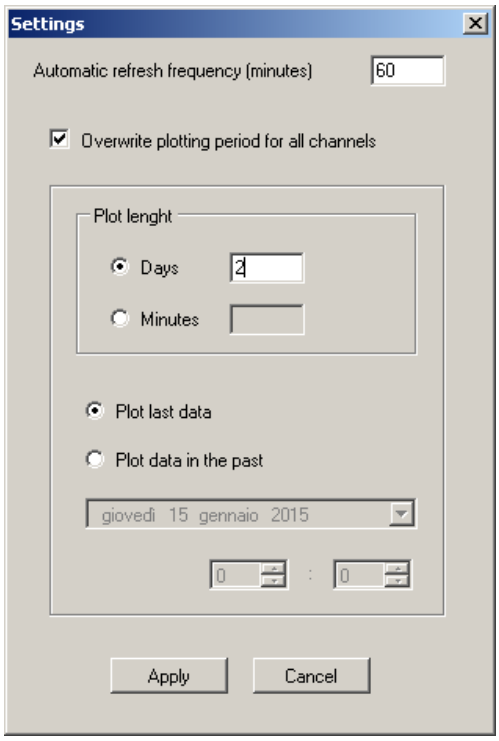
Each Monitor window shows the values of a single parameter (channel). Each instance of Monitor displays the channels belonging to a *MonitoringGroup*. A channel cannot belong to more than one *MonitoringGroup*, so if you have more Monitor instances, a single channel can compare only in one of them.
Once you defined a *MonitoringGroup*, you can configure the channels to be displayed on the current Monitor instances, by opening the menu [Channels][Configure].

The following configuration panel will appear:



12.7.2 Global settings

The global settings are accessible though the menu *File – Settings*.

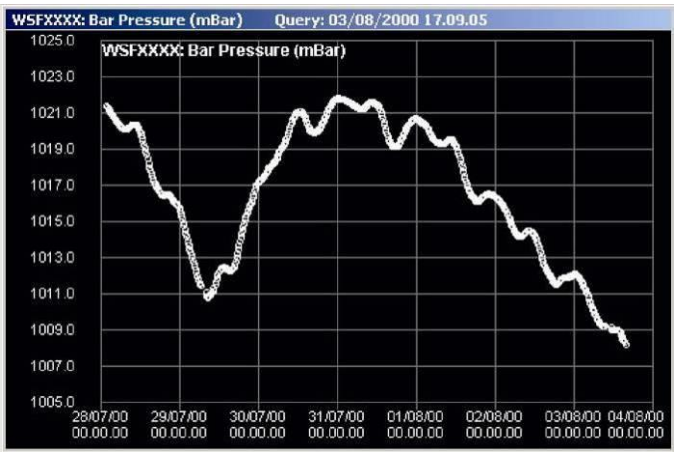


Automatic refresh frequency expresses the time between two refreshes of the charts. Edit this setting according to the sampling frequency: if for example the station takes flux measurement once every hour, it is useless to refresh the charts every 10 minutes.

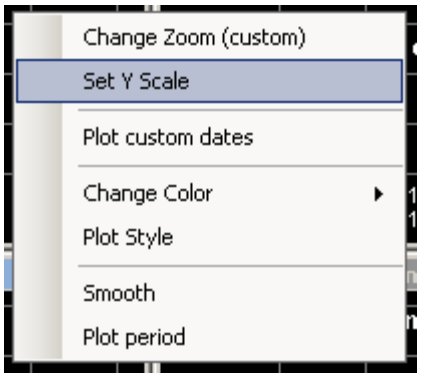
Checking the box *Overwrite plotting period for all channels*, it's possible to determine global settings that applies for all the charts. In this way Monitor will overwrite the settings that you may have previously edited with *Plot Period* and *Plot Custom Dates* menu (see next paragraph).

12.7.3 Chart appearance

By right-clicking on a chart window, you can modify the appearance properties of that chart, as the color of the grid, background, styles, filters.



With a right-click on the plot the following context menu will appear:



Change Zoom: changes the y-scale of the plot. This command will switch among 3 options:

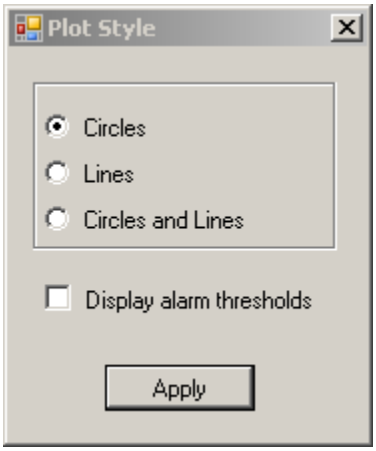
- Auto: selects automatically the best zoom fit
- Min-Max: it's the maximum zoom level that displays all the points.
- Custom: allows entering specific values (see Set Y Scale). Warning: this option will not display points outside the thresholds.

Set Y Scale: allows setting the minimum and maximum values to be displayed when in Custom Zoom mode.

Plot custom dates: By default, the last *x* days of data are plotted (where *x* is editable through Plot Period menu), so the right limit of the x-axis is the current day at midnight. Selecting *Plot Custom dates*, it's possible to plot any date in the past.

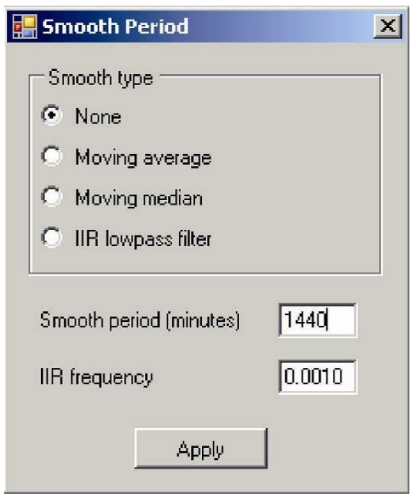
Change color: allows changing the color of grid, background, plot and labels.

Plot style: allows switching between points-based and lines-based plot. If you check the *Display alarms threshold* box, Monitor draws the plots basing on the value represented by the point. The values above alarm threshold are drawn red, the values in pre-alarm yellow and the rest green. If the box is not checked or the channel doesn't have any alarm limit set, the plot is painted with the default colour (see *Change color* menu above).



Smooth: allows applying a filter on the plot. Three filters are available: moving average, moving median and low-pass filter.

The *Smooth period* setting refers to Moving average and Moving Median filters. *IIR frequency* is the cut-off frequency of the low pass IIR filter.

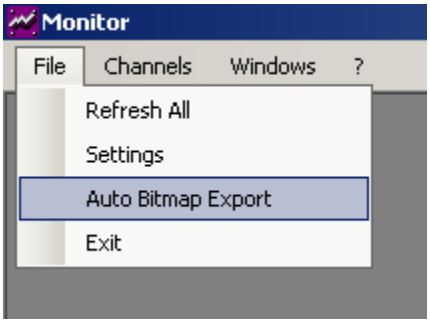


Plot period: Sets the time period to be displayed. Enter for example 14 to monitor the last two-weeks of data.

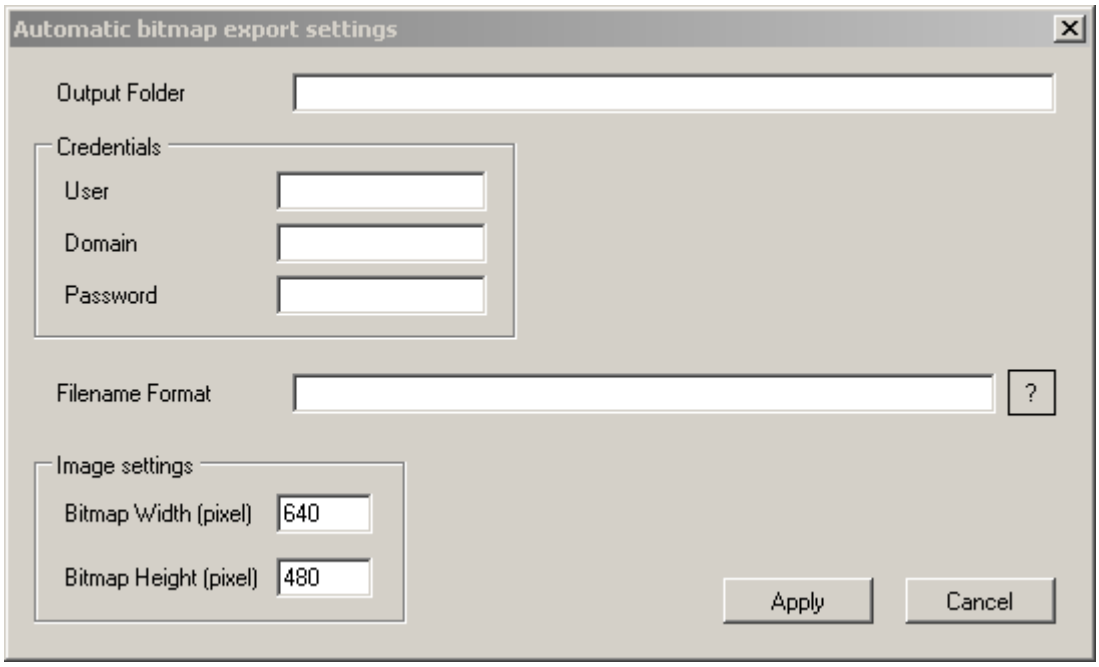
12.7.4 Automatic bitmap export function

Monitor can be configured to automatically export the generated plots to bitmap files.
The files are generated when the automatic scheduler of the application updates the charts (see global settings paragraph). To force the drawing and writing of the files, select on the menu [File][Refresh all]

To activate and configure the function, select [File][Auto Bitmap Export]



The following window will appear:



Insert into the field *Output folder* the path of the directory where you want to have the files saved. Remember that when setting the folder, the directory must exist. The application will try to access it when pressing *Apply*.

Examples:

C:\data\export
\\server\data\export

If the path requires particular credentials, because it is not accessible by the user which started the Monitor application, insert into the fields *User*, *Domain* and *Password* the needed credentials.
Otherwise just leave the fields empty.

Then insert into *Filename Format* a string that will be used by the software to assign a name to the saved file. You can insert into the filename the following keys:

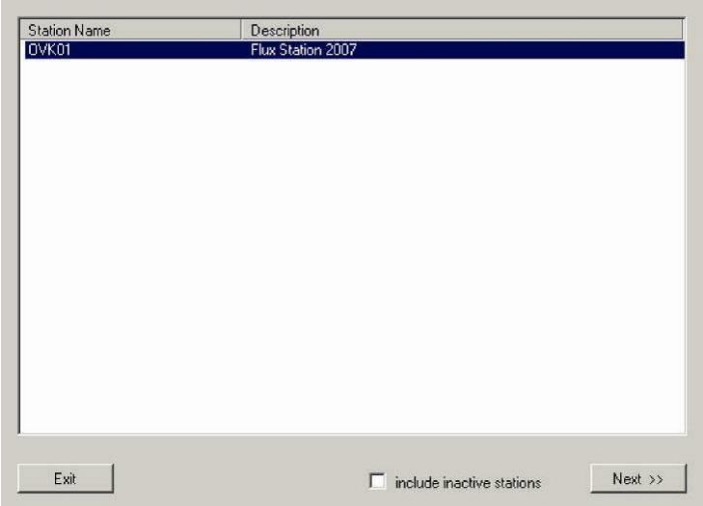
%station% : Name of the station
%chid% : Id of the channel (numeric)
%chname% : Name of the channel
%chdesc% : Description of the channel
%monitored% : Id of the chart
%querydatetime% : Date and time of the chart drawing
%querydate% : Date of the chart drawing
%lastsampledatetime% : Date and time of the last sample
%lastsampledate% : Date of the last sample

The default value is %station%_%chname%

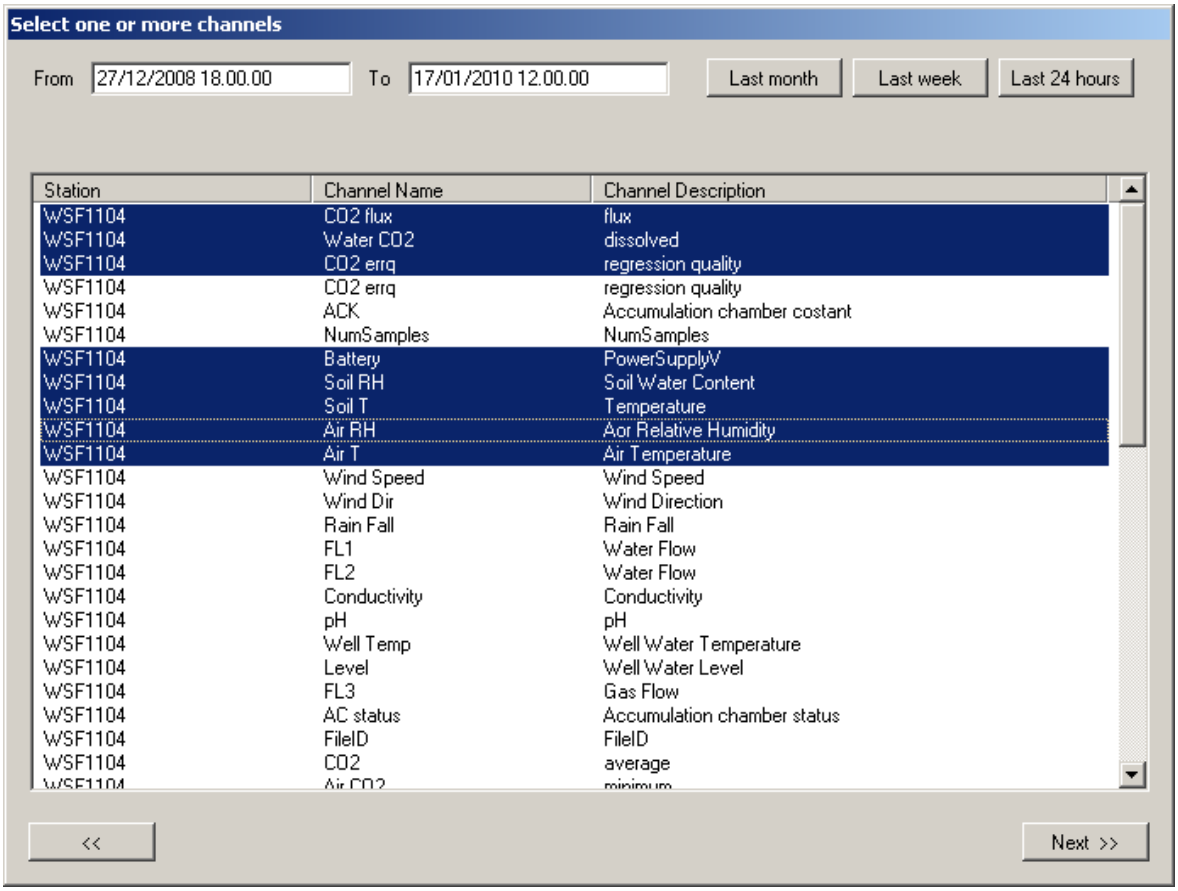
Any string which is not one of the listed key will be just replied into the name files.
Finally, insert into *Bitmap Width* and *Bitmap Height* the dimensions (in pixel) that you want the image files to have.

12.8 Query

The Query application allows you to extract the data from the database and to save into a Microsoft Excel spread sheet or into a text file (CSV comma separated value)
Run **Query** and select the station(s) you want to query.



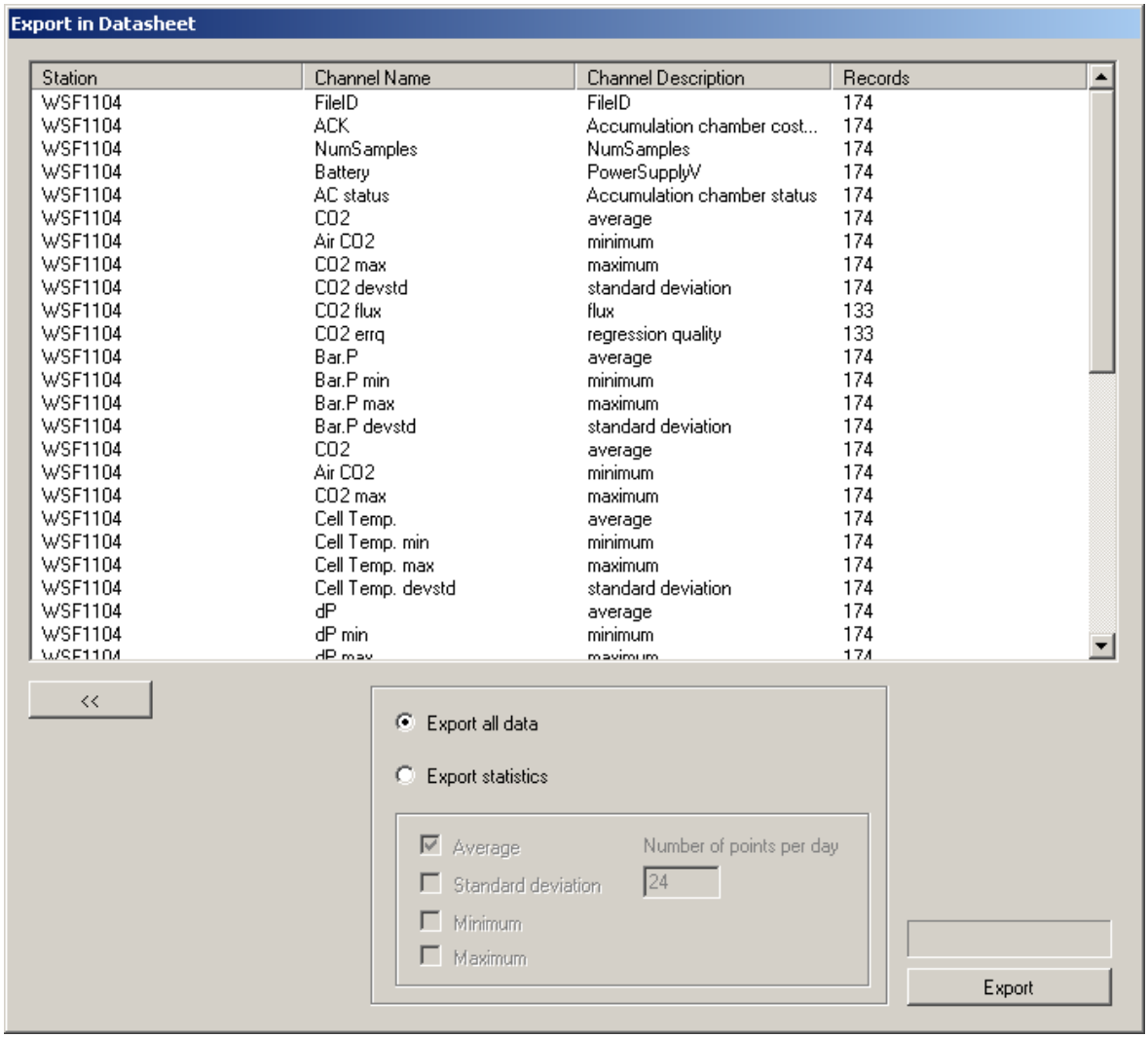
Press the [Next >>] button.



Set the date interval you want to query and Select the Channels then press [Next >>];

WEST Systems

The buttons [Last month], [Last week] [Last 24 hours] will help you by setting a "standard" time interval.



A resume of the query is reported: The column "Records" shows how many record are present in the time interval you selected for each channel;

By selecting [Export all data], you'll get a file containing a row for each record (and a column for each channel, plus one for the date/time).

By selecting [Export statistics], you'll get a file containing a number of rows corresponding on the specified "Number of points per day". For example, insert "1" for daily average, "24" for hourly average, etc. Query will generate for each channel one column for every checked statistic (average, standard deviation, minimum, maximum).

After pressing the button, you have to choose the format (Excel or CSV) and the output path.

13. GPRS/3G Telemetry

13.1 General considerations

The 3G telemetry system allows to remotely configure, manage and download the data from the station from any location using an internet connection.
The flux station is equipped with an industrial 3G router, model Westermo MRD-315.

Westermo MRD-315, front and rear view

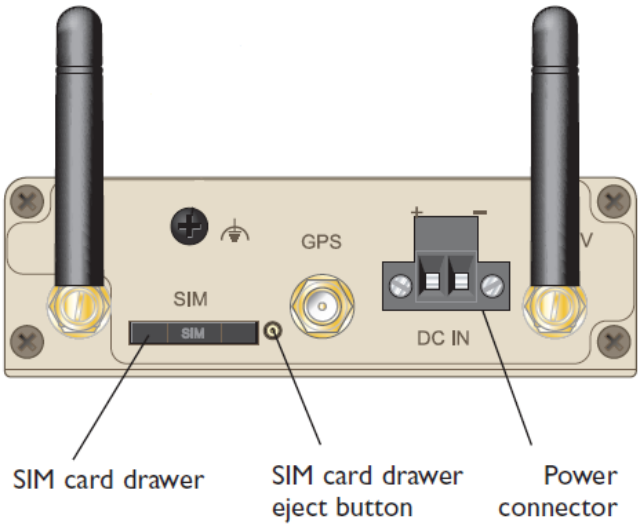
The MRD-315 has a double function:

- Mobile broadband router. It provides an Internet connection to the flux station;
- Serial server. It connects to the flux station RS232 port and make it available as a TCP/IP socket.

Using the second functionality, it is possible to connect locally with a laptop (on which the WS-Scada software has been installed) to the Ethernet port of the station and configure/download/test the flux station even if the SIM card is not inserted or inactive.

13.2 SIM Card

In order to remotely control the station, you need to insert a SIM card (not furnished) into the 3G router. Press the SIM card eject button using a suitable tool and remove the drawer. Insert the SIM into the drawer with the contacts facing up. Finally slid the drawer back into the unit ensuring that it locks into place.



We suggest disabling the PIN of the SIM card before inserting it into the router. The SIM card must have an active mobile data plan and a public IP address. If the SIM doesn't have a public IP address, it won't accept incoming connections and WS-Scada won't be able to directly connect to the station.

Note: in this case, a VPN tunnel must be established by the MRD-315. The unit integrates a VPN client using several technologies (IPsec, SSL, OpenVPN, WeConnect, PPTP), compatible with most VPN servers. The setup of the VPN tunnels requires an advanced configuration. For this purpose, please see the Westermo MRD-315 manual or contact *support@westsystems.com*).

The traffic generated by the 3G telemetry depends on the station sampling frequency and on WS-Scada polling frequency. It is anyway in the order of a few Kbytes per call, resulting in a few Mbytes per month. This amount of traffic is largely included in any mobile data plan offered by mobile operators at the date of this handbook release.

13.3 First connection

Preliminary operation:

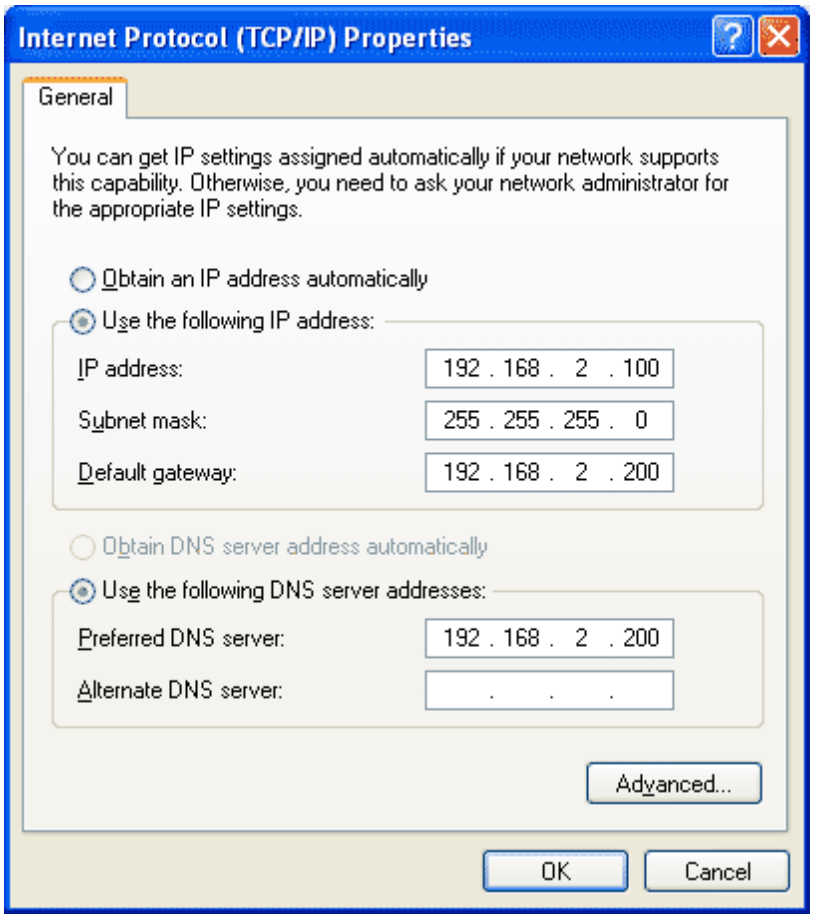
In order to configure the device and start using WS-Scada, you will need to connect a computer to the Ethernet port of the flux station. Before plugging the cable, configure the computer network adapter:

1. Open the Control Panel by selecting Start > Control Panel.
2. Double click the Network Connections icon.
3. Double click the Network icon.
4. The Local Area Connection Status dialog box will be displayed, click the Properties
button.
5. The Local Area Connection Properties dialog box, will be displayed. Click on Internet Protocol (TCP/IP) to highlight it and then click the Properties button.

The computer needs to have one of the two following network configurations

1) The computer has been setup to obtain and IP address automatically. In this case the MRD-315, which integrates a DHCP server, will assign a valid IP address in the sub-net *192.168.2.0/24*.

2) The computer has been setup with a static IP address. In this case the IP must be in the in the sub-net *192.168.2.0/24*. The following picture shows the suggested configuration.



More detailed instructions are available in the MRD-315 user manual, attached to this handbook.

In order to guarantee an easier maintenance, West Systems integrates the MRD-315 into the station leaving the fabric network configuration (with the exception of the DHCP being enabled) and user credentials.
The default IP address is hence 192.168.2.200.
Open a web browser on the PC and browse to http://192.168.2.200.
The administrator credentials are the following:
Username: *admin*
Password: *westermo*

If you are able to navigate the MRD-315 web interface, the network configuration is correct and you are therefore able to start the software WS-Scada and test the system locally.

13.4 Serial server

To enable the communication with the flux station, the MRD-315 serial server needs to be configured accordingly to the station RS232 port configuration. The unit is however shipped by West Systems already configured and tested.

Function: Raw TCP Client/Server
Network type: Accept
Accept port: 5001
Baudrate: 38400
Data bits: 8
Stop bits: 1
Parity: None
Flow control: None

13.5 Wireless network

To access the configuration page for the Wireless interface, click on Wireless. The Basic Wireless configuration page will be displayed.

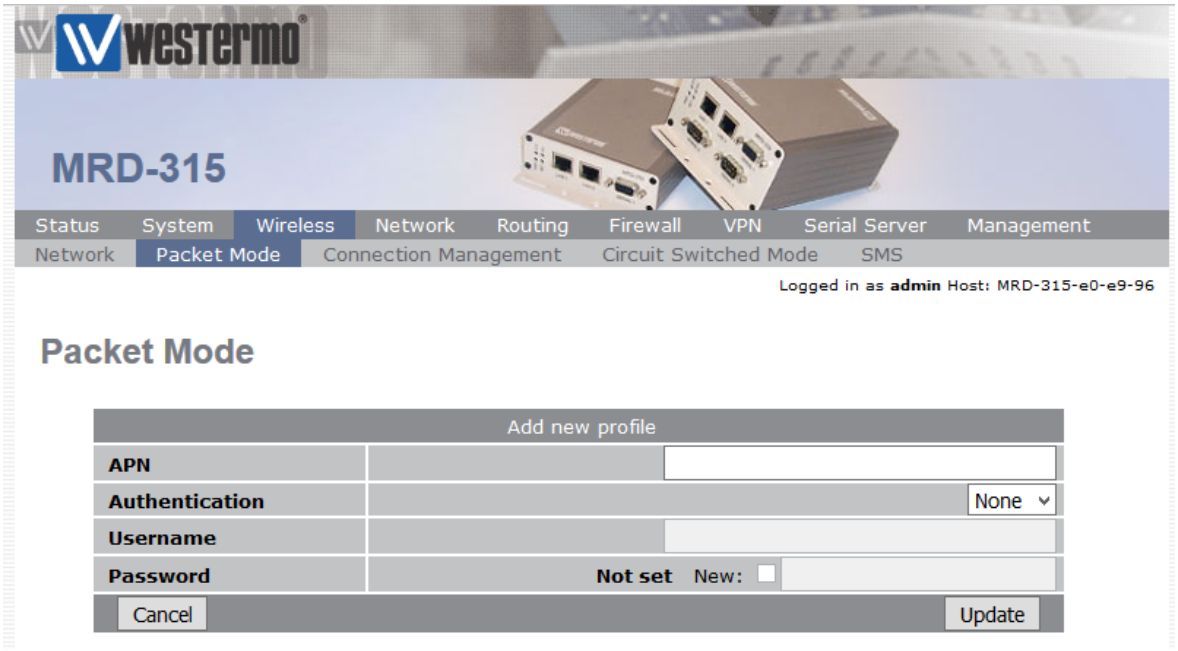
The ”Network Configuration” section contains the settings for the operational mode and the frequency band of the unit, the default settings will usually be adequate to connect the MRD to a packet based network.

Adding a Network Connection Profile
To access the wireless packet mode settings click on the ”Packet mode'' tab. The screen shown in Figure will be displayed.

The page shows the connection configuration details and is divided into two sections. The first section shows the current connection state for the selected profile. The second section lists the available profiles. A connection profile contains the settings required to connect to a provider's network. The unit allows multiple profiles to be configured to allow quick changes to the network connection settings. For most applications, only one profile is required.

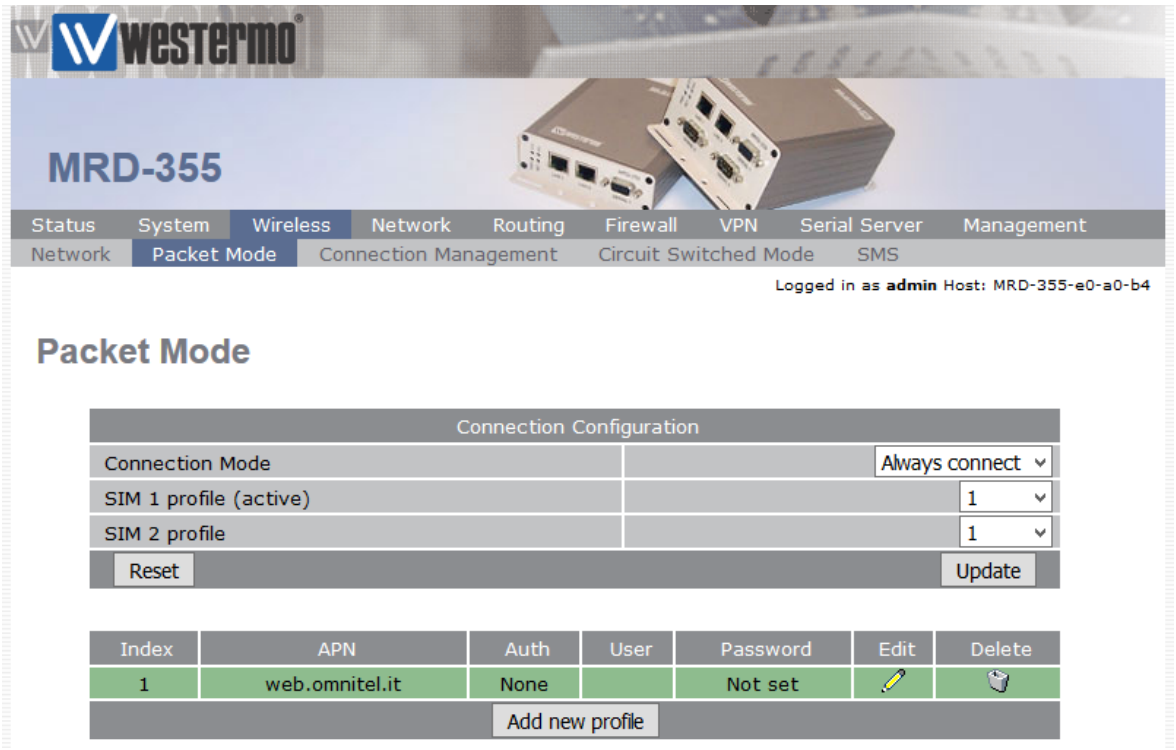
The 3G network provider will provide the items listed below which should be entered into the appropriate fields in the ”Add new profile” section as shown in Figure.

- APN (Access Point Name)
- Dial string
- Authentication (None/PAP/CHAP)
- Username
- Password



Note: In order to set a password click the check-box marked New. The password can now be entered in the text field. The password is visible as it is being typed so that it can be checked for errors prior to being set. Once set the password will no longer be visible.
Note: The provider may not supply a username and password if network authentication is not required. In this case set the Authentication to ”None”, leave the username blank and do not set a password.
Once the data has been entered click the ”Update” button to add the profile. The screen will now change to show the added profile. As this is the only profile entered it will be automatically selected as the current profile and the profile entry will be shaded green to indicate that it is the selected profile.

Enable the Wireless Connection
To complete the configuration of the wireless connection, set the ”Connection state” to ”Always connect” and click the ”Update” button to save the changes. Once the changes have been set, the MRD will initiate a connection. Normally it will take up to 30 seconds to establish a connection. The following figure shows the completed wireless configuration.



Checking the Status of the Connection

To check the status of the connection select ”Status” from the top level menu and then select ”Wireless” from the second level menu. The Wireless status page will be displayed which will look similar to the one shown in Figure.

The status of the connection will change as the router connects to the network, first it will report ”Checking” then ”Connecting” and finally ”Up”. To see the value changing the page will need to be reloaded.

13.6 Dynamic DNS

If the mobile data plan with public IP address that you’re going to subscribe with the mobile operator includes a static IP address, you can skip the current paragraph and proceed to configure the address in WS-Scada.

More likely, the public IP address will be dynamic: your network provider will assign a different IP address at every connection to the GRPS/3G/4G network. In this case, you’ll need to subscribe a Dynamic DNS service that will allow WS-Scada to know the current IP address in use.
Dynamic DNS is a system which allows the domain name data held in a name server to be updated in real time. The most common use for this is in allowing an Internet domain name to be assigned to a device with a dynamic IP address.

In order to use the Dynamic DNS feature of the MRD you will first need to register at a Dynamic DNS provider, the MRD-315 supports the following providers:
dyndns.com: http://www.dyndns.com/
no-ip.com: http://www.no-ip.com/
zoneedit.com: http://zoneedit.com/
easydns.com: http://www.easydns.com/

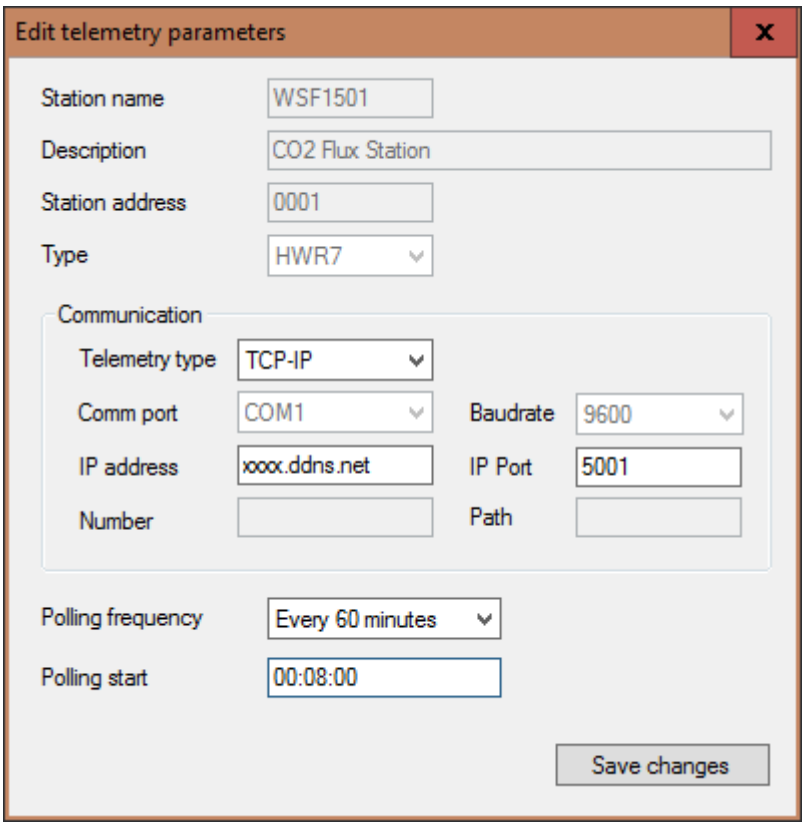
Once registration is complete follow the steps below to configure the MRD, for reference Figure 51 show an example configuration.

1. Click the Network tab on the main menu, then select DNS from the sub-menu, this will display the DNS page, the Dynamic DNS settings are in the section titled Dynamic DNS Client Configuration.
2. Tick Enabled checkbox.
3. Select the service provider from the Service drop-down menu.
4. Enter the Domain in the Domain text box.
5. Enter the username for your account in the Username text box.
6. Enter the password for your account in the Password text box.
7. Click the Update button to save the changes.

13.7 WS-Scada configuration

To configure WS-Scada to use the GPRS/3G telemetry, execute the following:

- Open WS-Scada, select [Options][Show Advanced Menu]
- Right-Click on the name of the station you want to set, press [Edit Telemetry]



- Select TCP-IP as [Telemetry Type]
- Input into the [Port] field the port number 5001 or whichever port you configured in the MRD serial server.
- Input into the [IP Address] field the static IP address obtained by your mobile provider (example 92.92.92.92) or the DNS name registered by the DDNS provider (example xxx.ddns.net).
- Press [Save changes]
- Restart WS-Scada.

13.8 MRD-315 Status

The status of the unit and the mobile network can be checked through the two status LEDs on the front of the MRD-315. The meaning of the indicators is resumed by the following table.

LED	Status	Description
STS Status	RED	No wireless network has been detected
	RED FLASH	A wireless network has been detected
	GREEN	Power up self test OK/no issues
NET NET 1 NET 2 Network indicator	OFF	Not ready
	RED	RF circuitry initialising or network registration fault
	GREEN/RED	Network connection fault
	GREEN FLASH	Searching for network
	GREEN	Locked to network
	GREEN 1 BLINK	Signal strength indication 1 Very poor 3 Normal 6 Very good
	GREEN 2 BLINKS	
	GREEN 3 BLINKS	
	GREEN 4 BLINKS	
	GREEN 5 BLINKS	
	GREEN 6 BLINKS	

The status indicator reports the health of the unit. In normal operation, the indicator will be green, if a fault is detected either at boot-up or during normal operation the indicator will light red. When the unit is first switched on or is reset, the indicator will first light red, then flash red in sequence with the Network Indicator, this is normal behaviour during boot-up and does not indicate a fault. The indicator will light red or green a short time after power is applied. If the indicator does not light when power is applied check the power supply voltage and connections.

The network indicator reports the status of the connection to the network. When powered up the indicator will be off, the indicator will then flash green whilst the unit searches for a network, once connected to the network the indicator will light green.
Once a network connection has been established the Network Indicator reports the level of the received RF signal as well as any network connection faults. The

signal strength is indicated by the number of green flashes of the indicator within an indicator period. Each indicator green flash will be followed by a short off time, an extended off time indicates the end of the indicator period. So an indicator period starts with a green flash followed by up to 5 additional flashes, then an extended off time, the cycle will then repeat. The maximum number of flashes in an indicator period is 6. The indicator may be red during the extended off time following the green flashes, this indicates a network connection fault. The indicator will flash red if a SIM card is not present and will be solid red if the RF circuitry is restarting, network registration has failed or the RF signal level is 19 too low for a connection.
When the unit is first switched on, or is reset the indicator will first light red, then flash red in sequence with the Status Indicator, this is normal behavior during boot-up and does not indicate a fault.

The MRD-315 offers a wide range of additional functionalities (which includes routing, firewall, VPN, etc.) whose treatment goes beyond the scope of the present handbook.

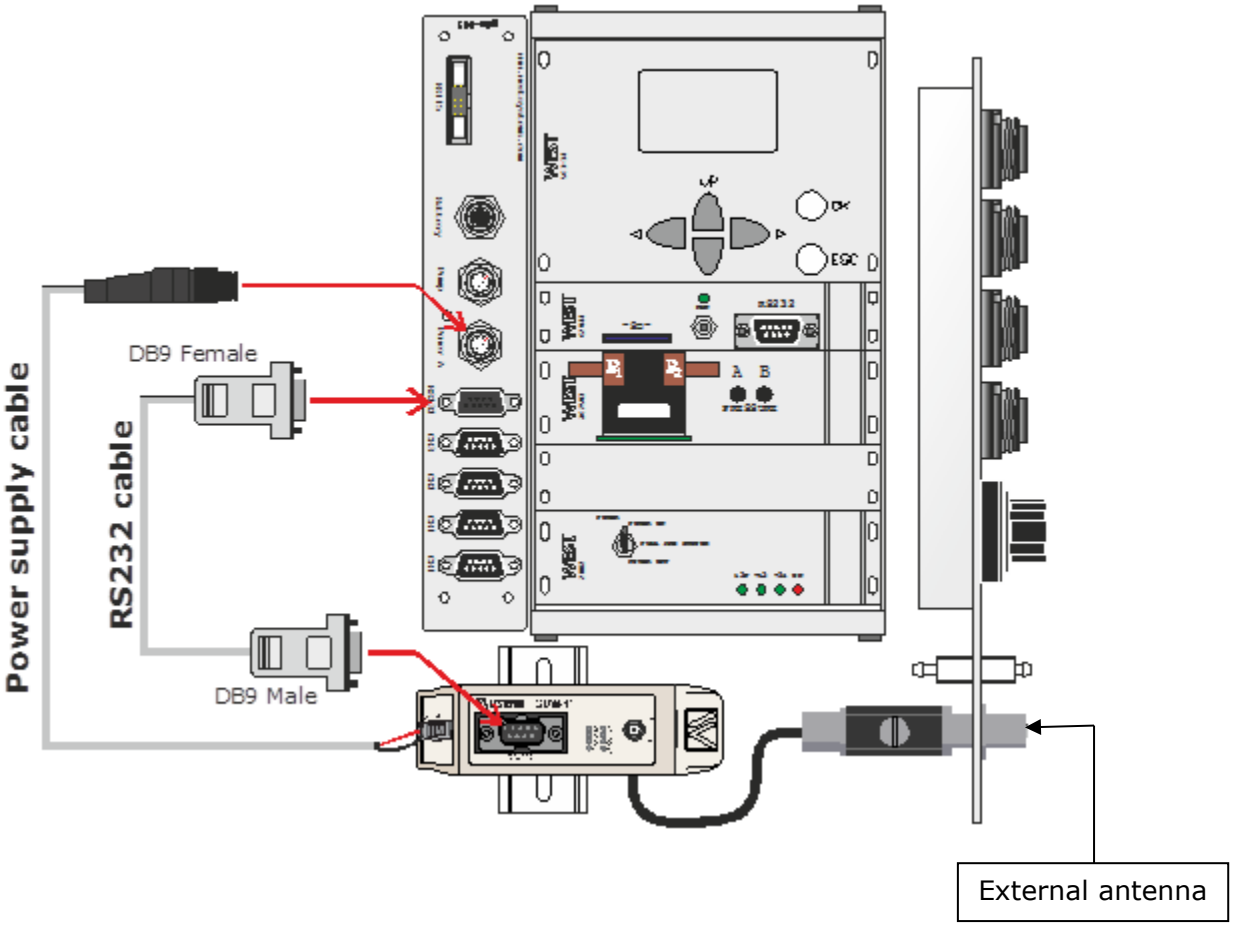
13.9 Antenna

In order to optimize the signal of the router, West Systems provides a quad band GSM/GPRS/3G omnidirectional external antenna.

Please ensure that power is disconnected from the unit before connecting the antenna. Don’t use the router if the antenna is disconnected.

Connect the antenna to the N-adapter as indicated in the following figure.

13 GPRS/3G Telemetry



Specifications
Manufacturer: Siretta
Ordering code: Delta 6A
Gain (peak): 6.8 dBi
Connector type: SMA Male
Supported bands: 850 (GSM) MHz, 868 (ISM) MHz, 900 (GSM) MHz, 915 (ISM) MHz, 1800 (GSM) MHz, 1900 (GSM) MHz, 2100 (3G) MHz

© www.westsystems.com
Continuous Monitoring Flux Station
Release 3.3 January 2017