EMS Brno

Data Acquisition Environment

Hardware – Software – Cloud application

www.emsbrno.cz

Datalogger GreyBox N2N

User's manual

September 2019 – 4-th issue

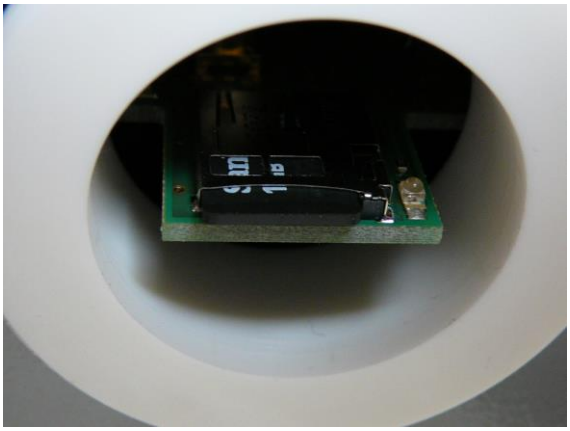
Content:

1. General description

N2N means the abbreviation of Network-to-Network. The datalogger is primarily intended for data transfer from SDI-12 sensor network to Internet. On-line data are supposed to be sent to EMS cloud application which is made for comfortable data handling in terms of visualization, downloading, archiving and maintenance. However, the data can be sent also to FTP server or to user's computer running EMServer2016 application. Those options will be available later.

The datalogger is equipped with internal memory enough for ca 220,000 values which are easily accessible from outside via infrared port.

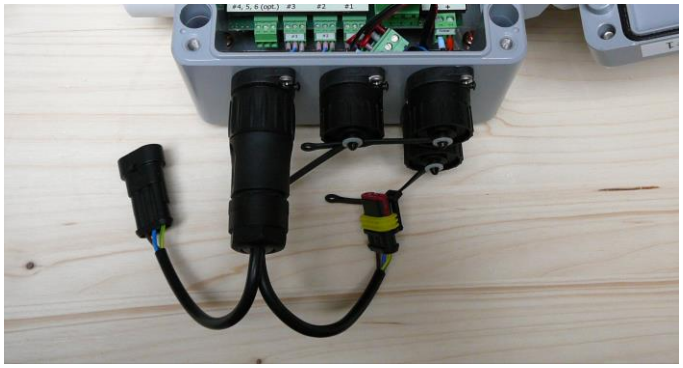
Besides, there is also SD memory card installed inside the enclosure and accessible after removing a screw plug.



This plug also serves as a case for two easy replaceable desiccant bags.

The transparent pin in the center of plug is a light guide for IR communication.

The datalogger is built-in to a heavy water-resistant aluminum box with high level of protection against water – IP65. The box is equipped with a holder for fixing to 50 mm pole but it will survive also when just laid down on the ground. Robust Amphenol C16-1 connectors make the whole set ready for harsh environment.



Note: Interconnection of sensors in SDI-12 network by means of Superseal 3-wire connectors shown in the picture above is reliable, low cost and easy to handle.

The N2N datalogger has integrated flexible system of powering. It allows powering from internal primary cells, from 0.8 Ah internal lead acid battery or from external lead acid battery with capacity up to 100 Ah.

Both internal or external lead acid batteries are recharged after connecting of solar panel without any external controller.

Note: When internal lead acid battery is stored inside the box but the system is powered from an external battery, the internal battery is continuously refreshed in order to keep its lifetime. However, a simple changeover of two plugs inside the box is required always when the way of powering is changed.

The datalogger has three ports for connection of three independent SDI-12 networks. Each port can be powered continuously or in measuring period or only in the period of averaging (storing to memory).

Note: Basically, the datalogger measures and stores to memory averages of measured values. Therefore, we are talking about intervals of measurement and averaging/storing.

Continuous powering is necessary for those sensors which must be supplied with power for their operation – typically sap flow sensors. Sensors measuring variables with high dynamics (radiation sensors) must be sampled frequently – each measuring interval. On the contrary, sensors measuring slow processes might be measured less often; in those intervals when the average of quickly measuring variables are averaged and stored do the memory. Therefore, from the point of view of energy consumption, it is good idea to connect fast and slowly measuring sensors to different ports.

Sending data to Internet is principally possible once each hour or always in the interval of averaging. This choice and the hours when the transmission is allowed are programmable by user.

2. Main features

- Three SDI-12 ports (optionally six ports)
- Supports SDI-12 standard version 1.3
- Built in GPRS modem
- Built in GPS module
- Ready for solar powering without an external controller
- Alternative powering from eight internal AA cells
- Low power consumption (ca 350 μA between measurements)
- High protective rating IP 65
- Storage capacity 220,000 values accessible wirelessly via IrDA interface
- Easily accessible SD memory card sufficient for many years of measurement
- Continuous measurement of temperature and humidity inside the enclosure
- Sensor library for fast and comfortable configuration of SDI-12 sensor network
- Advanced Windows® software for datalogger configuration, data retrieval and processing

Note: By six-port version the powering of ports 4 to 6 is in parallel to ports 1 to 3.

3. Specification

Number of SDI-12 ports	3 (optionally 6)
Datalogging part:	Non-volatile memory, 512 kB
Capacity of internal memory	ca 220,000 values, not volatile memory (optionally 440,000)
External memory	SD card up to 32 GB (micro SD or micro SD HC formatted for FAT12, FAT16 or FAT32)
Measuring interval	10 sec up to 4 hrs (limited by number and type of sensors)
Averaging interval	10 sec up to 4 hrs (limited by number and type of sensors)
Modem activity	In selected hours, once per hour or in intervals of averaging
Modem antenna	External, flat arrangement, 2.2 dB gain
Exciting sensor voltage	Equal to power supply voltage; 10 to 16 Volts, fused
Overvoltage protection	Diode suppressors connected to each port
Power supply	Internal or external lead acid battery completed with solar panels or eight internal AA mono cells (alkaline o Li-FeS2
Solar panel	Nominal voltage 12 V, up to 120 W
Recharging capacity	10 A, protected against overloading
Battery capacity	Internal lead acid 12 V; 0.8 Ah, external up to 100 Ah
Power consumption:	
- idle	Ca 350 uA
- transmitting data	Ca 30 mA (without sensor powering)
System back-up	Lithium coin type battery CR2032; 3 V
Back-up battery lifetime	5 years at least
Protection	IP 65
Size (L x W x H)	210 x 180 x 115 mm (optionally 280 x 180 x 100)
Weight	2.5 kg (without internal batteries)
Operating range	-40 to 60 deg.C

4. Description and functions

4.1. Data averaging

Measured values are saved directly or (more often) as an average within certain time interval. For instance, the logger measures every minute, calculates the hourly average and saves this value each hour to the memory.

In this context, two different time intervals are defined:

- measuring interval
- interval of averaging/storing

Both intervals have to be set as an integer fraction of minutes or hours and the ratio of both intervals has to be integer number, too. Therefore, there is only limited number of time intervals available: 1, 2, 3, 4, 5, 6, 10, 15, 20, 30 (seconds, minutes) or 1, 2, 3, 4 hours. As an advantage, datalogger has to measure each whole minute and hour which suits to calculation of minute, hourly or daily averages.

Values of both intervals are checked by the software during the system configuration. Moreover, minimal time period is limited with respect to number of sensors and its specifications. The maximal time period is limited by hardware features to four hours.

4.2. Data format

Despite of text format of data outgoing from sensors, measured values are stored as two-byte integer numbers in a kind of database format. This way saves not only the memory space but also duration of data transfer to a connected PC or to GSM network. The conversion to technical units is performed later in cloud application or in the computer running Mini32 software. All information necessary for the conversion is stored in the downloaded file.

4.3. Internal memory

Downloaded file has an extension HEX and its length in bytes is roughly twice the number of stored values. The conversion to DCV format used by Mini32 software for data visualization and processing is offered during the downloading procedure. However, the HEX file can be opened and converted to DCV any time later. Since the channel configuration in HEX file is editable, potential error in configuration can be fixed before the conversion to final values. See Mini32 user's manual for details.

Export to another format (text, MS Excel) is supported by Mini32 software.

4.4. Memory card

A memory card up to 32 GB can be inserted to the datalogger from outside after removing a screw plug. Micro SD or micro SD HC should be used. It must be formatted for FAT12, FAT16 or FAT32 system. With respect to compressed data format the storage capacity of 8 GB card reaches tens of years of storing of 200 variables each ten minutes. Daily files in HTF format are saved twice a day and they are easy processed by Mini32, too.

4.5. Internet data access

N2N datalogger is primarily intended for on-line sending data to EMScloud Internet application. For this purpose, it contains a built-in GPRS modem with external antenna.

Modem can be programmed for sending data in selected hours or in each interval of data averaging. Because of compressed data format, the transmission is fast and the length of transferred files is quite short (tens of kB a day).

4.6. Cloud application

In the cloud application, there are two data sources:

- Download of visualized data directly from graphic screen to text (CSV), Excel (XLSX) or Mini32 (DCV) format. These data can be a subset of the whole data set with respects of hidden variables. On the other hand, it may contain new variables calculated from directly measured variables.
- Archive data. They are saved on the cloud server as daily files with extension HTF, exactly at the same format as they are saved on memory card. They are raw data containing all hardware relevant information. Those data files in user selected days are downloaded in compressed format with extension EDP. When opened in Mini32 related software, those files are automatically converted to DCV format and they are joined into one file of exactly same format as those files downloaded from the datalogger in the field.

Note: The access to data which belong to certain user are carefully protected against unauthorized persons. However, the owner of the measuring system can delegate the approach to another people for limited time period.

4.7. SDI-12 connection

All sensors matching SDI-12 standard are connected to common three-wire network. Be aware that all sensors connected to this SDI-12 network must be introduced in Mini32 software library. The datalogger has three (optionally six) individually configured SDI-12 ports. Note: Extended ports are powered in parallel with first three ports: 1+4, 2+5 and 3+6.

The sensor connection is easy but it requires that each sensor connected to the same port has unique address otherwise this part of network won't give any value. The configuration of SDI-12 sensors is intuitively supported by Mini32 software.

4.8. Operation with datalogger

There are no operating elements here like display or keyboard on the datalogger. Datalogger configuration, data download and maintenance can be performed only by means of the computer and Mini32 software. Apart from communication with dataloggers, Mini32 offers large number of functions for efficient data visualization and processing. The software development started on the 1998 with main respect to fast processing of long-time data series.

Exchange of desiccant bags and manipulation with memory card are accessible after removing the screw plug.

4.8.1. Communication with PC

There is only the possibility of wireless communication, there are neither RS232 nor USB connectors available. A special USB/IrDA cable is required. The head of this cable contains a magnet which "wakes up" the datalogger. The communication is hold for the time when the cable head sits on the screw cap (there is a metal ring holding the cable) and the Mini32 is running.

The communication is supported by Mini32 software which is compatible with all EMS dataloggers and smart sensors.

4.8.2. Operating indicators

There is only one red LED indicating status of operation. Its light is visible through the screw plug. There are three operation status indicated:

- No light – datalogger is sleeping or sending data to infrared port in regular intervals ("Regular reading"). It allows to Mini32 drawing variables in real time.
- Slow blinks with period of 0.6 sec indicate datalogger activity – measurement or data transmission.
- Continuous light means that the datalogger communicates or it waits for communication. It supposes running Mini32 and the cable head sitting on the screw cup.
- Very fast blinks after turning on the power lasts eight second: During this time period the is the system ready for recovery after a total crash. A special software is required in such an extreme situation.

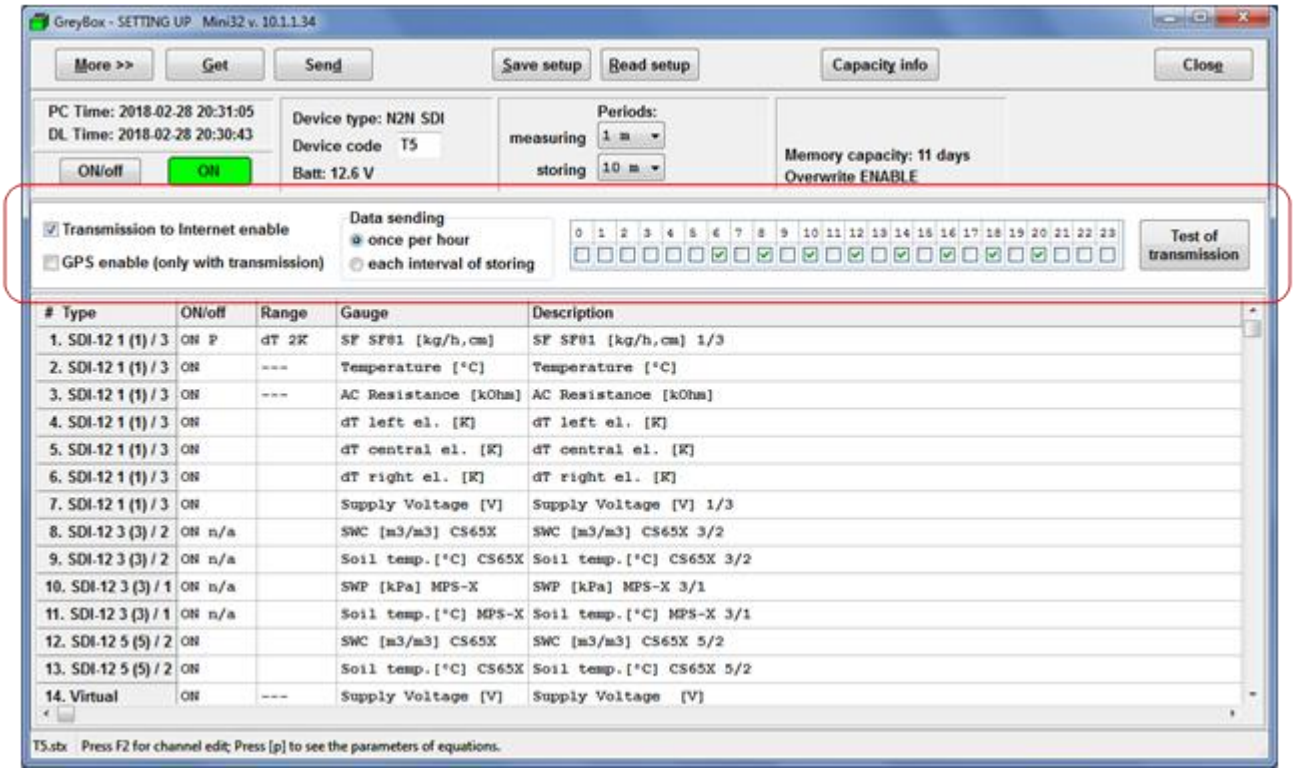
Note 1: Datalogger starts communication mode after approaching the cable head to the screw plug. If there is no communication attempt within one minute, the datalogger

returns to normal operation. It gives time to unready users for starting Mini32 and/or for finding the proper working directory. Similarly, the logger keeps communication mode still one minute after removing the cable head or turning off Mini32.

Note 2: There is also a green LED indicating modem activity, but it is hardly visible from outside. Anyway, the modem status is approachable in Mini32.

4.8.3. Modem setting

An additional panel regarding to modem setting is displayed in Configuration screen of N2N datalogger:



In this window, the user can decide the way of data sending to EMS cloud application (if at all) and whether the measured GPS coordinates should be added to transmitted data.

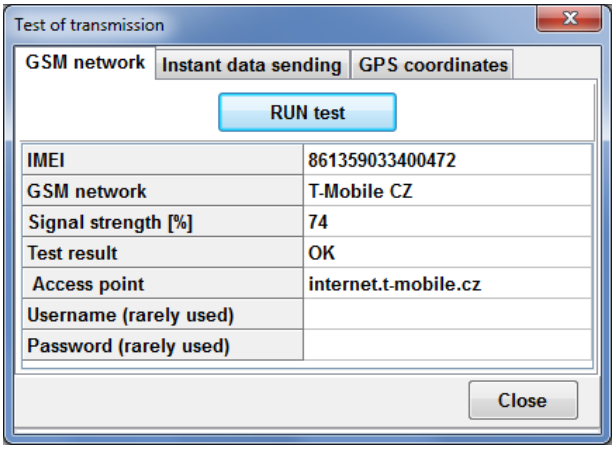
Note 1: Estimation of GPS position has sense only when data are sent to cloud application. They are displayed on locality page.

Note 2: Sending data in intervals of hours is common way. In case when the very fresh information is demanded on-line, the data can be sent in each time when the data are saved to datalogger memory.

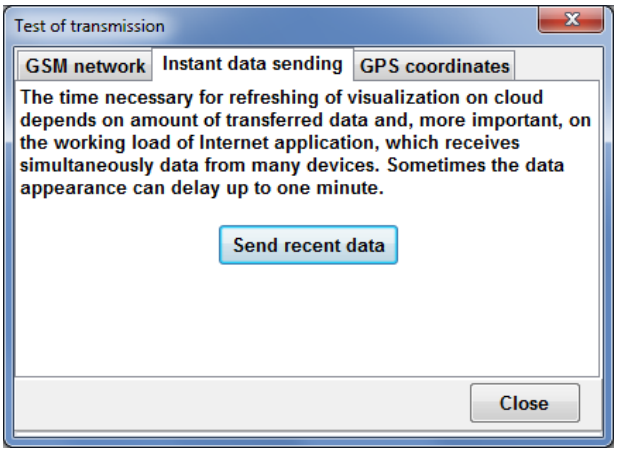
Note 3: If the memory card is inserted, current daily data files are saved to the card twice a day at 2 a.m. and 2 p.m.

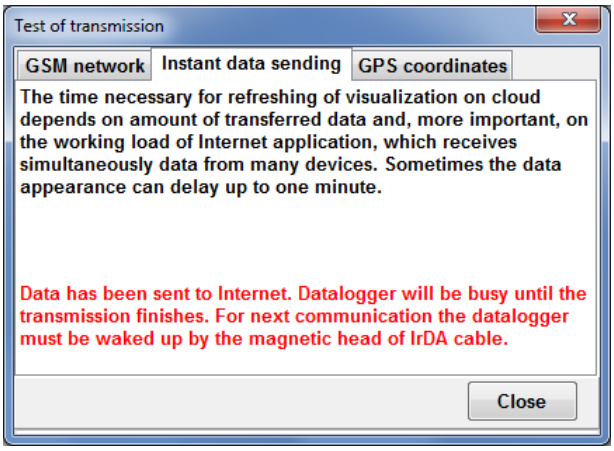
The "Test of transmission" button opens next window where GSM network properties can be shown and send current daily values to cloud application.

Checking of GSM network is available in first tab. It usually takes ca 15 sec. The result of test is shown in table:

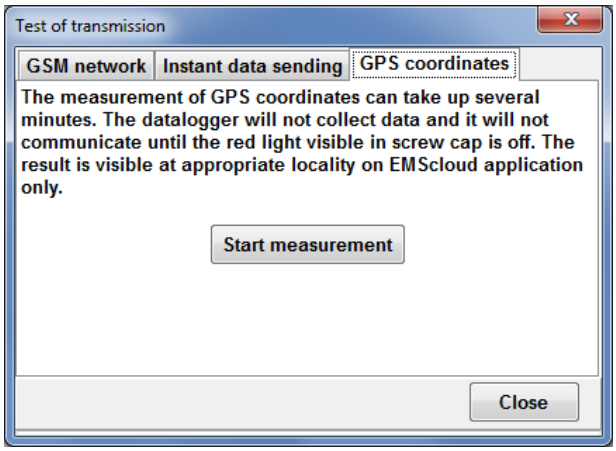


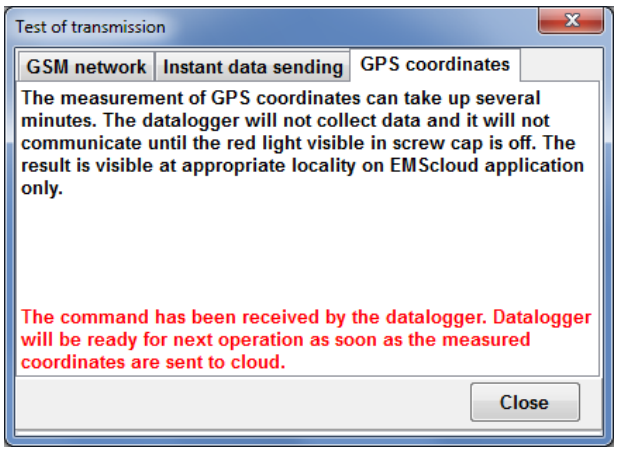
Instant sending data to cloud application can be performed is second tab. The user is informed that the datalogger received the command and sent data to Internet but result of this operation is visible in cloud only – there is impossible to check the success of data sending directly here:





The last tab allows to send GPS data to the cloud application. The coordinates will be displayed on the locality page.





4.8.4. Internal buttons (inside the box)

There are two buttons placed on the front panel visible in opened enclosure.

- System reset – it cancels all current operations. Use in an emergency case when the system stuck and it does not response to communication attempts. It is similar to turning the datalogger off and on again.
- Instant data sending. The datalogger will transmit data to cloud independently on programmed time schedule. It should be used for testing purposes or for cloud configuration when the first data set is desired. This operation can be performed from Mini32 as well.

5. Connection of power supply

There are three ways of power supplying:

- From internal primary cells
- From internal sealed lead-acid battery
- From external recharged lead-acid battery (mostly by solar panel)
- From external power source

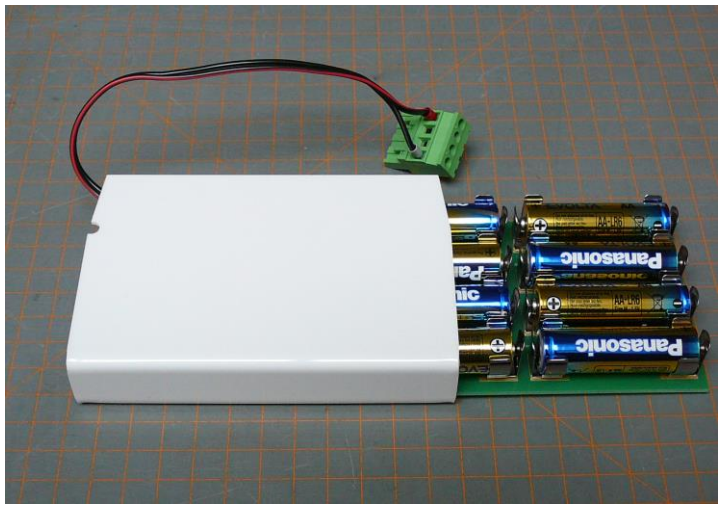
5.1. Internal primary cells

Eight alkaline of Li-FeS_2 AA size batteries with approx. capacity 2 Ah are inserted in a special holder and placed in a slot inside N2N enclosure. The box lid must be unscrewed for battery replacement.

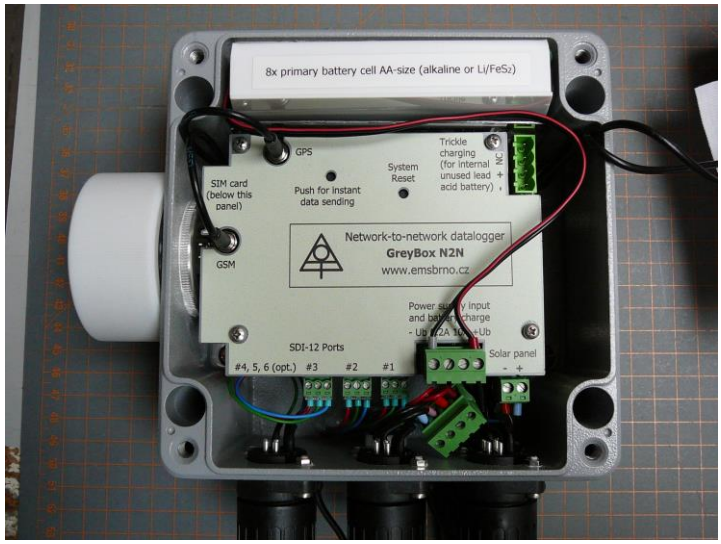
Lithium based batteries are much longer lasting in comparison with alkaline batteries, mainly because only little voltage decay during their lifetime.

This way of powering is recommended when there is not enough radiation energy for solar panels and when sensors are powered at longer time intervals (tens of minutes or hourly) and data transmission is required less often.

The battery pack consist of PC board with battery holders which is inserted freely in a plastic enclosure:



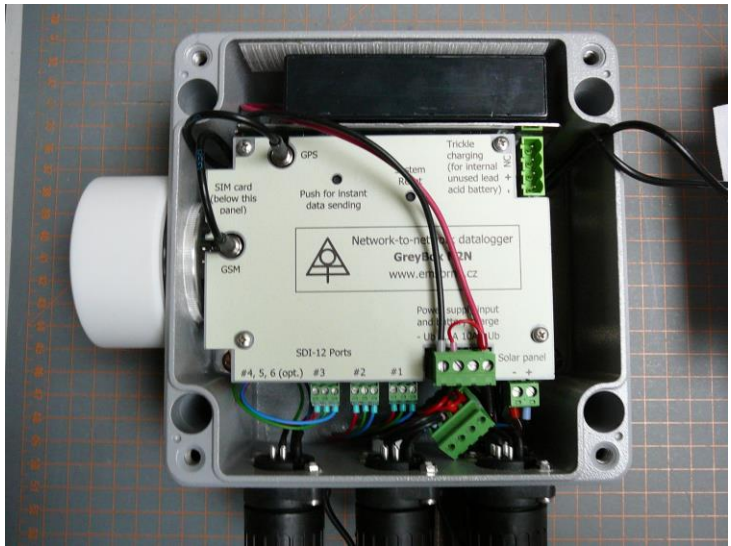
The internal wiring is shown here. The connector from external power is pulled out and it is replaced with the battery connector.



5.2. Internal sealed lead-acid battery

There is space for one 12 V, 0.8 Ah battery only. Such a battery should be used with a small solar panel for powering of not too much energy demanding sensors. The solar panel can be connected directly since the system takes care of battery charging.

The internal connection is the same as with primary cells:

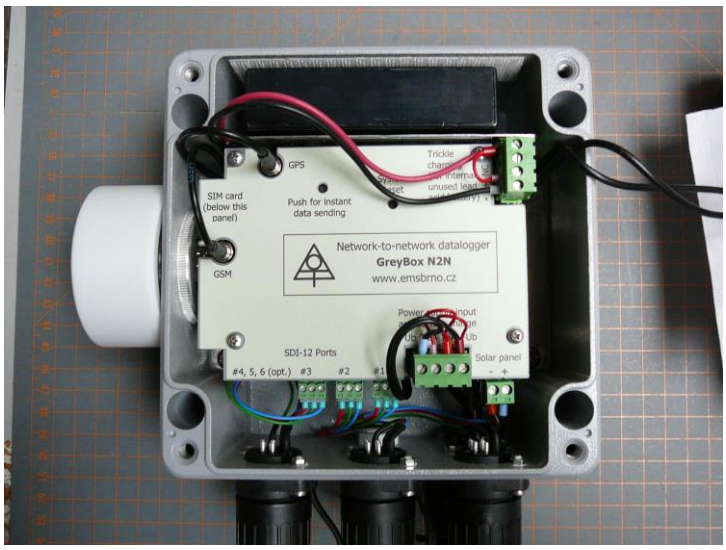


Note: Recharging of internal battery from an external AC/DC power adapter instead of the solar panel is also allowed. The power adapter must have DC output

voltage in the range 16 to 30 Volts. It should deliver 500 mA at least and it must be connected instead of solar panel.

5.3. External lead-acid battery

This is the way for powering of "thirsty" sensors in combination with solar panel/s. Especially for systems which should run unattended for long time period of low solar radiation (winter, north latitudes). Big battery will make necessary energy buffer for such a situation. When the internal lead acid battery is sometimes used on a different opportunity, it can be stored in its compartment and continuously refreshed with small current (ca 50 mA) from the main power source. The cabling inside the enclosure looks like this:



5.4. Powerful external power source

If there is an electricity available on the measuring plot, the logger can be powered directly from a good quality 12 V power supply unit without a battery. Please be advised that not each power supply unit is suitable for direct powering od electronic devices. The output voltage should be smooth, without drop-outs and voltage spikes. The voltage can range between 10 and 16 Volts. This arrangement is recommended for power demanding sensor (many sap flow meters for instance). Otherwise you can opt for the solution according to paragraph 5.2.

Never connect external power unit as solar panel! Solar panels and power adapters have totally different specifications.

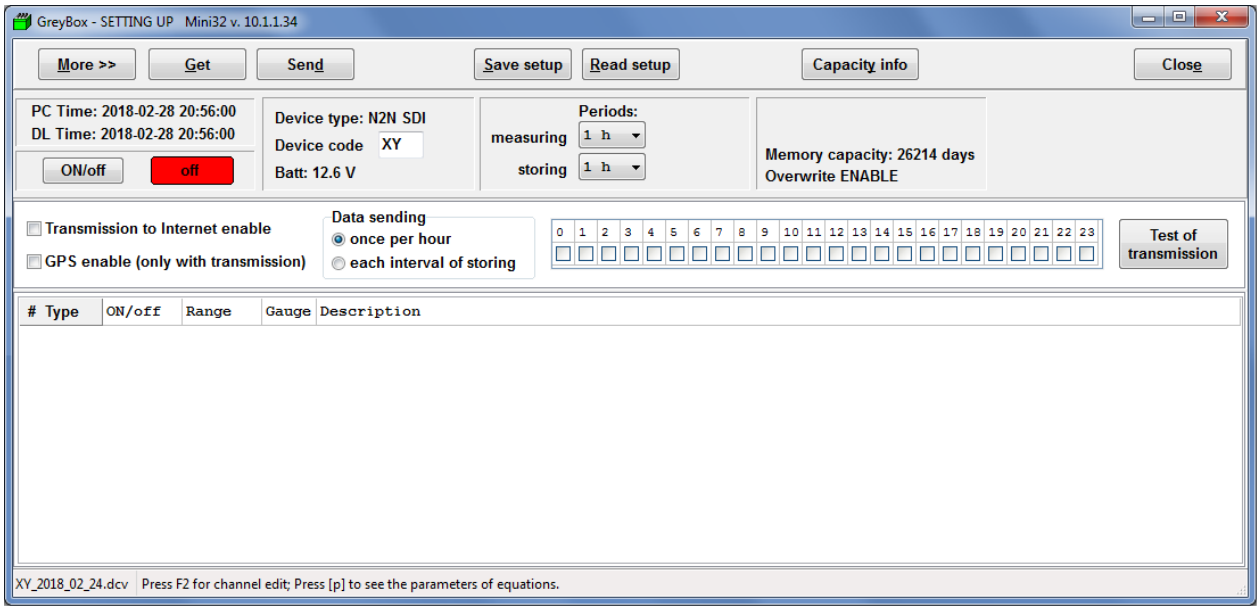
6. Datalogger configuration

The datalogger configuration is intended in order to be the most similar to standard analog setting. Therefore, after configuration of SDI-12 sensors, the user will be moved to "analog" environment with possibilities to change parameters of those sensors which offers this option. Be advised that this datalogger can handle only with sensors from the Mini32 library. However, manufacturer is continuously adding to library all sensors which are used by customers.

Configuration business can be divided into next steps:

- Scanning SDI-12 network(s) for available sensors
- Selection of measured variables from offered measuring modes
- Configuration of sensors (if it is possible on connected sensors)
- Configuration of time intervals of the measurement and data transmission

At new dataloggers, when pushing "Configuration", the default factory configuration of the datalogger looks like this:



The datalogger operation is stopped, device code is XY and both time periods of measurement and storing to memory are set to one hour. No sensor, no measuring channel does exist. The battery voltage in the example above is 12.6 V. When the logger is supplied from lead acid battery (internal or external, there is no difference at this point), this value indicates nearly fully charged battery. Voltage of the set of internal alkaline mono cells should be about 12 V, in case of primary lithium cells Li/FeS2 up to 14 Volts.

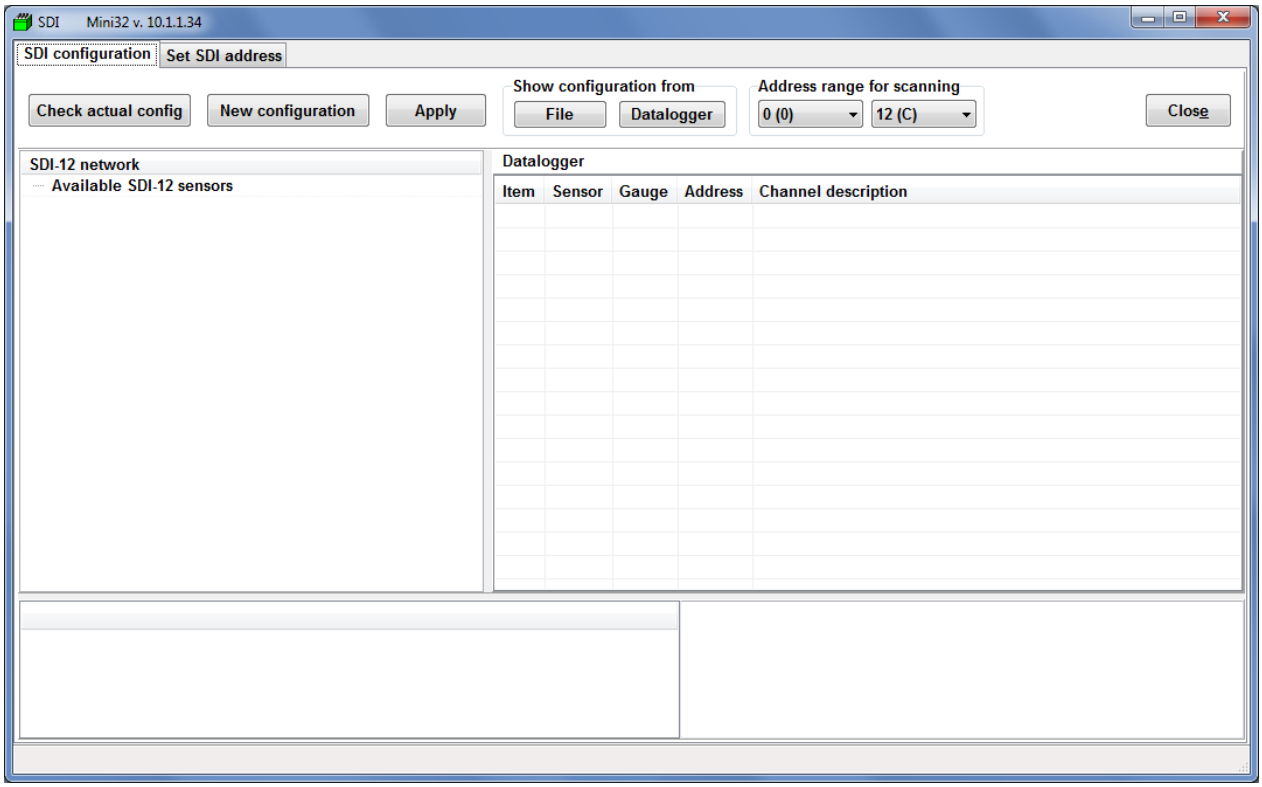
6.1. Configuration of the SDI-12 network

Since the datalogger has three independent ports for connecting three SDI-12 lines, it is good idea to think about connection of sensors to certain line. Principally, there are three types of sensors from the point of powering and frequency of measurement:

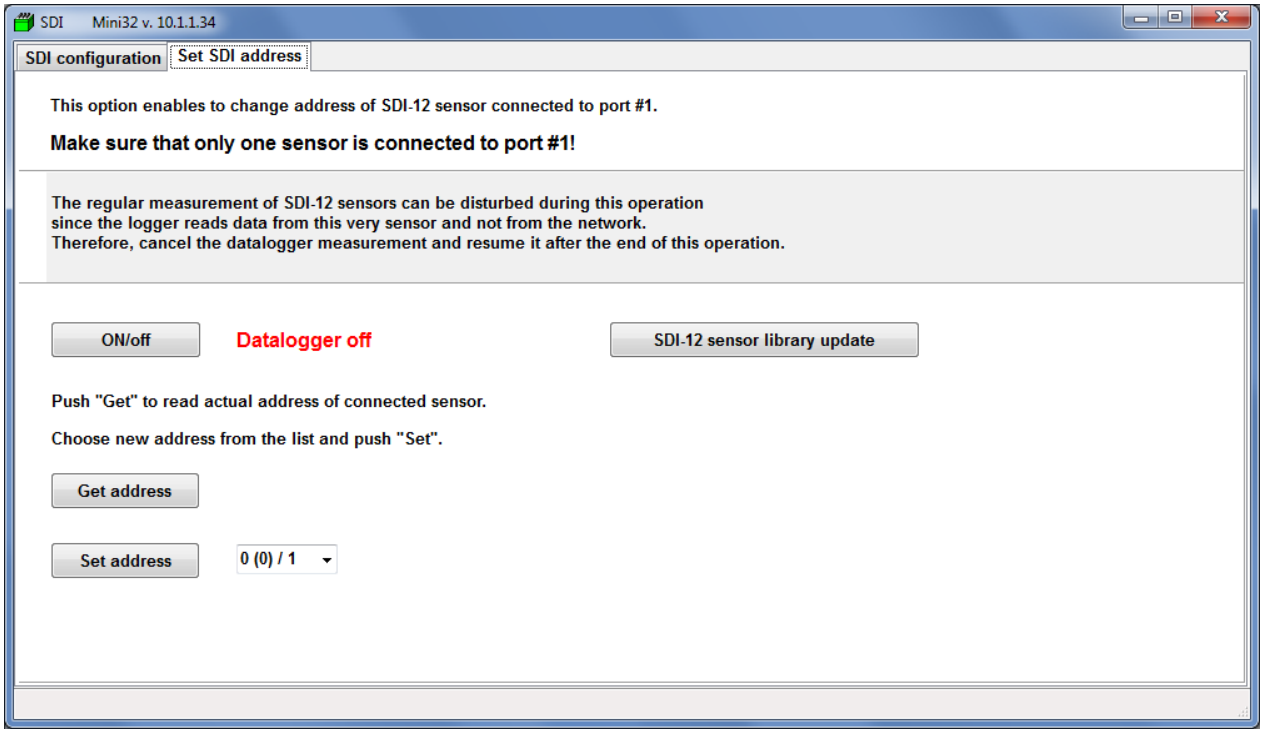
- Sensors which must be powered continuously – typically sap flow sensors, rain gauges, water flow meters, ultrasonic wind sensors etc.
- Sensors which can be powered only when they are measuring but the measurement is quite frequent – typically radiometers, air temperature and humidity meters, mechanical wind sensors etc.
- Sensors which measure slowly changing variables like soil water status, soil temperature, ground water level, snow cover depth etc. Those sensors can measure in larger time intervals – averaging – if there is a limited energy source.

Before the scanning the network, all sensors have to be connected and, the most important, **each sensor connected to the same port must have unique address otherwise the whole network connected to this port will collapse**.

Configuration of SDI-12 network is fully supported by Mini 32. Push "Configuration" then "More>>" and "SDI-12 config":



For setting the addresses, **only one sensor** is allowed to be connected **to port #1** of the datalogger. Mini32 supports the setting of the sensor address in the tab "Set SDI address":



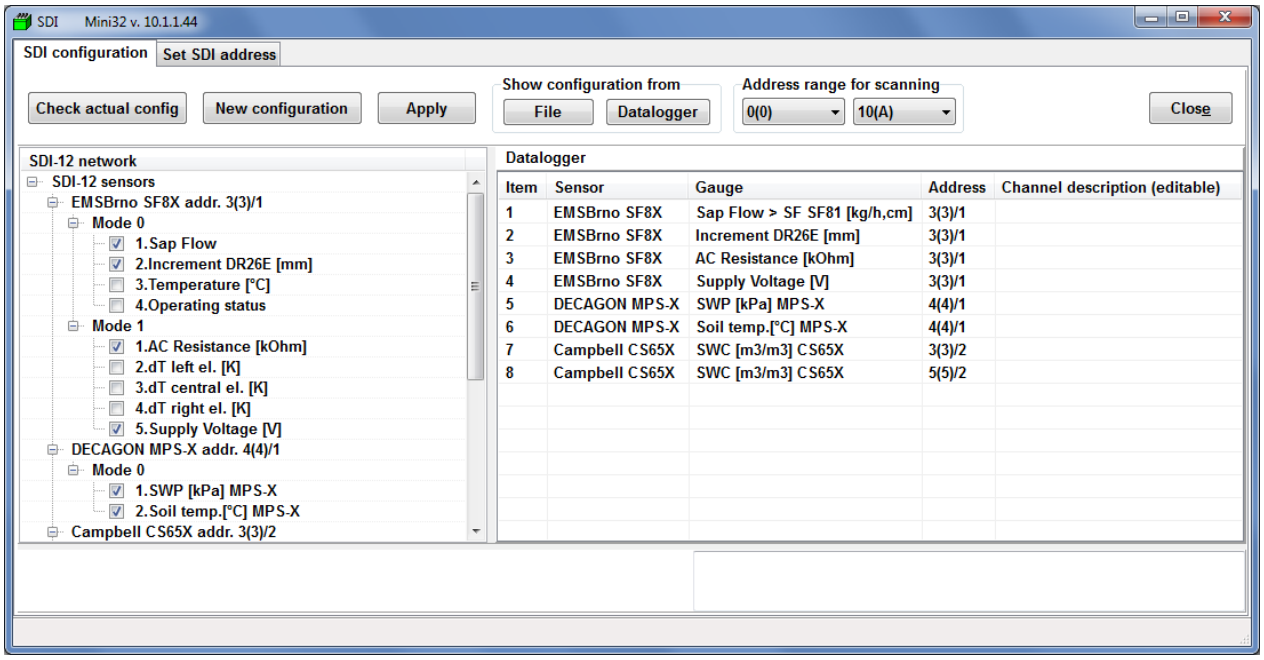
Addresses on different ports are independent – different ports can have even the same set of address.

Before you run new configuration please do not forget to set the **range of sensor addresses** – smaller range than the highest address of connected sensors will omit those sensors, uselessly high number would significantly prolong time of scanning the network.

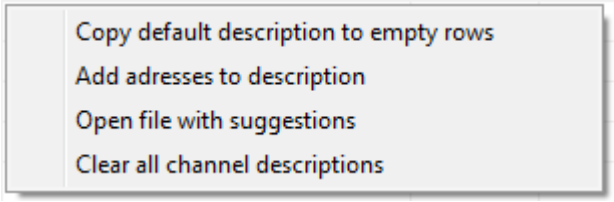
6.1.1. Scanning of the network

Push "New configuration" button.

All sensor connected to the datalogger appear in the left window. Use drag & drop method for changing of sensors order. Then, expand measuring modes one by one and chose variables which should be measured:



Edit channel descriptions manually (double mouse clicks at each line) or use possibilities available in pop-up menu in right window:



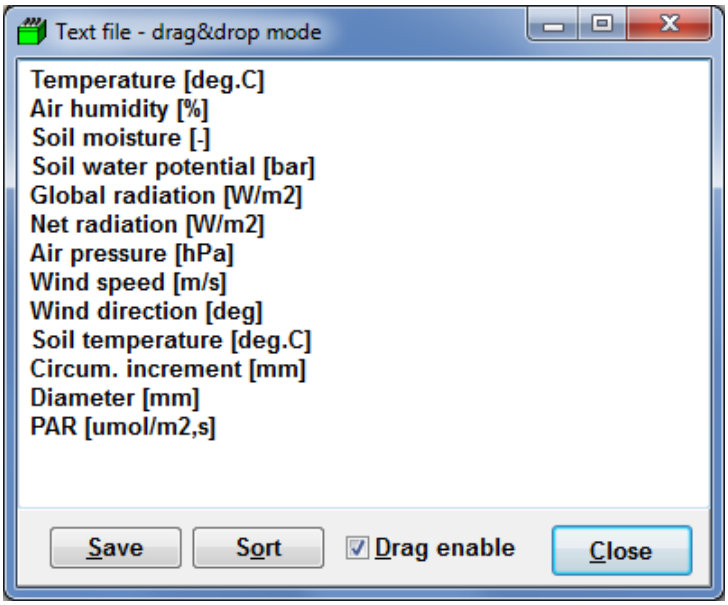
There are two sources of suggested channel description:

- Default description is included in sensor library. It skips name of manufacturer and it is composed of variable name and units. See following example:

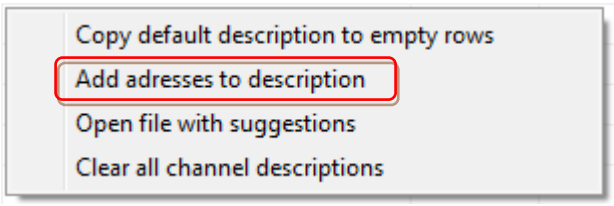
Datalogger

Item	Sensor	Gauge	Address	Channel description (editable)
1	EMSBrno SF8X	Sap Flow > SF SF81 [kg/h,cm]	3(3)/1	SF [kg/h,_]
2	EMSBrno SF8X	Increment DR26E [mm]	3(3)/1	Increment [mm]
3	EMSBrno SF8X	AC Resistance [kOhm]	3(3)/1	AC Resistance [kOhm]
4	EMSBrno SF8X	Supply Voltage [V]	3(3)/1	Supply V SF8X [V]
5	DECAGON MPS-X	SWP [kPa] MPS-X	4(4)/1	SWP [kPa]
6	DECAGON MPS-X	Soil temp.[°C] MPS-X	4(4)/1	Soil T [°C]
7	Campbell CS65X	SWC [m3/m3] CS65X	3(3)/2	SWC [m3/m3]
8	Campbell CS65X	SWC [m3/m3] CS65X	5(5)/2	SWC [m3/m3]

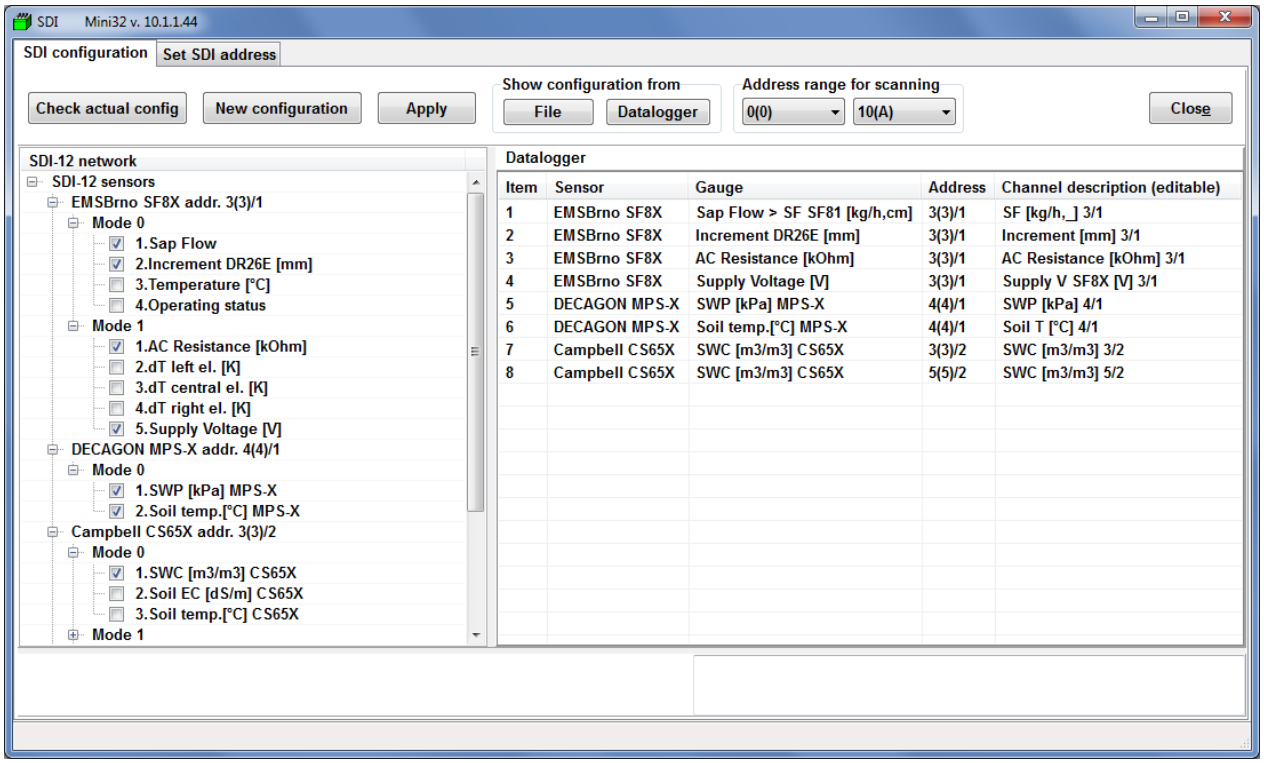
- Simple text file containing user defined terms and notes which are useful in case of frequent use of the same words, also in different languages:



Note: For better view over the configuration, there is also possibility to add sensor address and number of ports behind to the channel description (second line in pop-up menu):



Finished configuration of SDI-12 sensors will look like this:



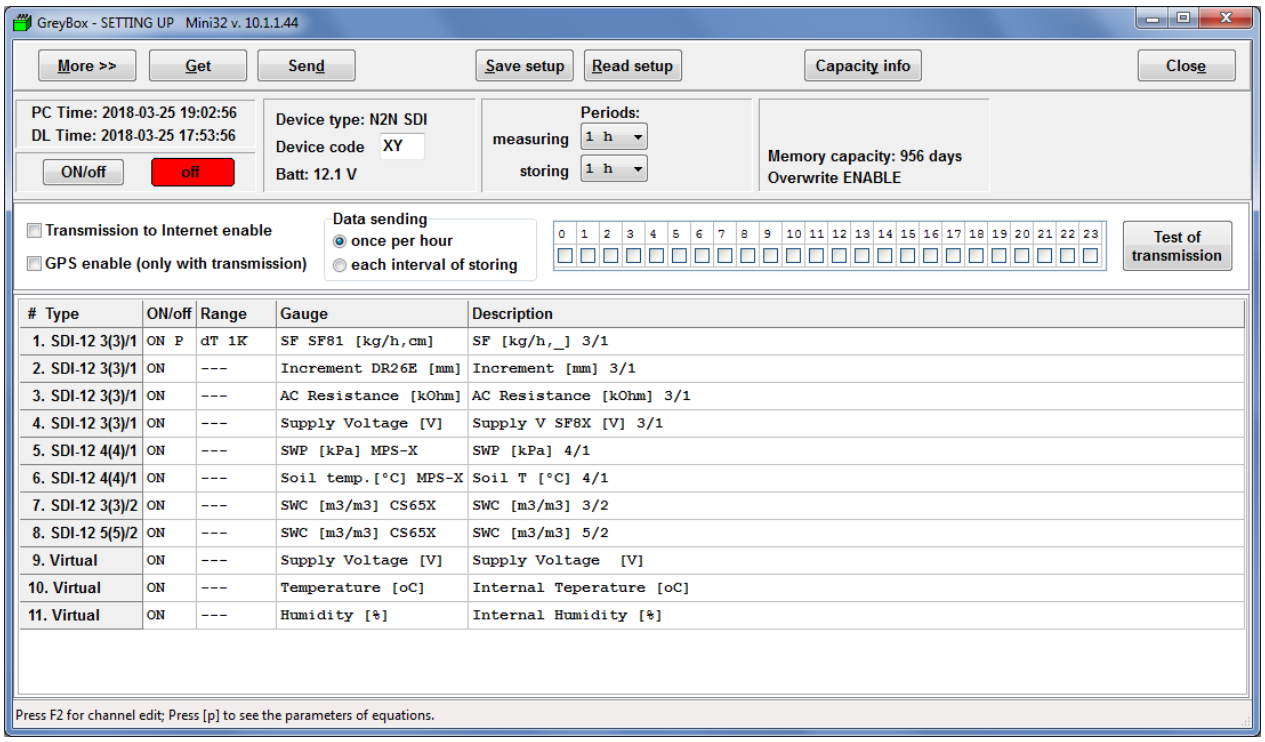
Note 1: Sensor address is a bit complicated issue, since it must contain only one character: 0, 1, 2, 3, …. 9, A, B, C, ….. Z, a, b, c, … z; 62 available addresses altogether. For easier overview we also show simple numbering 1 to 62. Number of port is behind the slash. Therefore, the address looks like 12(C)/1. In default channel description, the value in parenthesis is omitted.

Note 2: Variable (channel) description can be edited even later in next configuration window.

Note 3: The cloud application strictly requires different channel descriptions in one datalogger in order to avoid a confusion among variables in cloud application. Be aware that variables displayed in cloud are identified according to description only. Entering address and port numbers makes channel descriptions different.

When the configuration is finished, push apply. The standard "analog" configuration will be displayed in next window.

Note: "Analog" configuration screen originates from analog dataloggers. It serves to organize data in files as regular matrix with the same number of variables in each row.

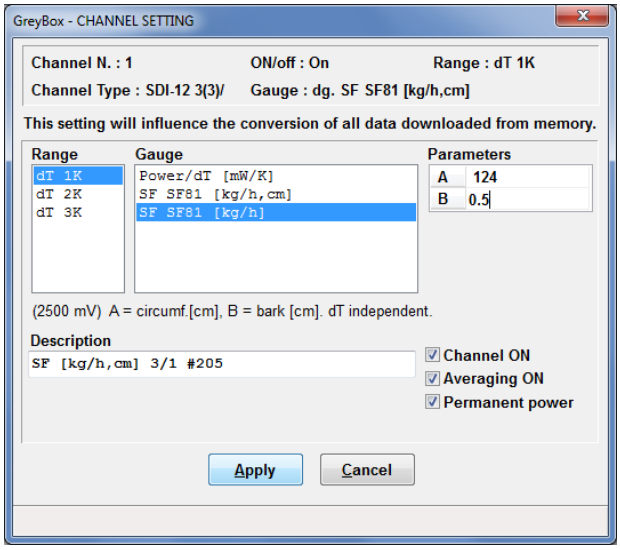


Note: Please notice three "virtual" channels on last positions. Those variables which measure power supply voltage and internal environment are added automatically but they may be turned off.

6.1.2. Finishing of configuration

This screen looks as a virtual datalogger containing analog sensors. Each line represents one variable coming from digital sensors. In the first column it is displayed the address of "parent" sensor and the port to which the sensor is connected.

Be advised that there are some next settings of each channel. Double click on the line will open the channel configuration. For instance, the configuration window of sap flow sensor looks like this:



In the upper left window can be changed the temperature difference in the measuring point. Higher value reduces the

influence of ambient temperature gradients and makes the measurement more accurate but it proportionally increases the power consumption.

Upper right window offers to choose the output sap flow unit: Whole tree sap flow or the sap flow rate for 1 cm of stem circumference. First choice is better for standard processing, the second one is better in terms of comparison between trees or species. For the calculation of whole tree water uptake is necessary to enter tree circumference and the bark thickness. See EMS81 user's manual for details.

Variable description can be edited here as well.

Note: This configuration can be also edited in HEX file before conversion to DCV format!

Three checkboxes on the righ side says to datalogger how to power the sensor and in which interval should be this variable measured – always or in those times of averaging and storing to the memory. In this very case the most important is the last checkbox since sap flow sensors must be powered continuously.

The result of channel configuration is shown on the main configuration screen. The way of measurement and powering is displayed in second column. For instance

"ON" means the masurement and powering in each measuning interval

"ON n/a" means the powering and measurement only in times of averaging

"ON P" means continuously powered sensor measured in each measuring interval

"off" means the this variable wont be measured

"off P" means that this variable wont be measured but the SDI-12 line must remain continuously powered because of to other sensors or variables etc.

Generally speaking, gauge selecting is possible by some channels only but timing of measurement and powering of sensor should be checked at each channel. This setting is shown in the configuration screen by each channel.

Note: Sensor library of Mini32 contains information on those sensors which must be powered continuously and set the "P" automatically.

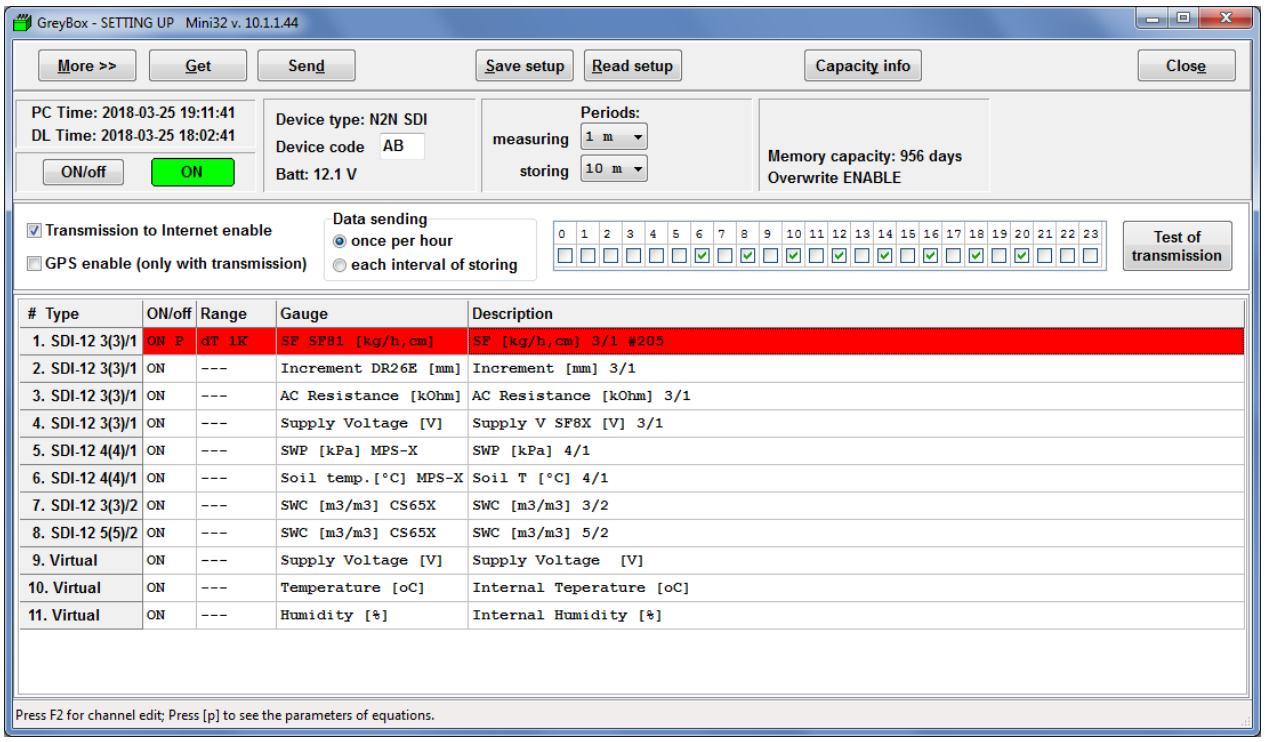
Finally, the general parameters which have to be edited:

- Device code. Two characters – numerals or letters – will be used for identifying the files created by the datalogger if the user did not edit the filename before saving.
- Measuring time is the time interval between consecutive measurement of the datalogger. Storing time is the time span between consecutive records in data file. At this time are saved in datalogger memory average values from the measurement performed during the averaging period or it is saved the last measured value only. If the only last value in averaging time is demanded (wind direction for instance), the "Averaging ON" checkbox must be unchecked.

Here is also information concerning the datalogger:

- Memory capacity is calculated on the end of configuration and it is refreshed after uploading configuration to datalogger. It shows number of days until the oldest data are rewritten with newest ones or the datalogger stops operation.
- "Overwrite ENABLE" allows measurement after the memeory is full. The oldest data are overwritten with newest data, then. It is set at during datalogger initialization. Note that it relates to internal memory only. If there is a SD card installed, the memory size is large enough for many years of measurement.

As for buttons located in the grey field above:



- More>> - opens the higher level of configuration including datalogger reset (Init) and SDI-12 configuration
- Get - reads configuration from datalogger
- Send – uploads configuration to datalogger
- Save setup – saves configuration to file for next use
- Read setup – read configuration from file. Be careful – using is limited by equal hardware configuration!

- Capacity info – shows expected battery lifetime and memory capacity of virtual combination of measurement with SDI-12 sensors supported by Mini32 library

White panel in the middle of the window regards to configuration and testing of data transmission to EMScloud. See paragraph 4.8.3.

When the configuration is finished, turn on the datalogger by pushing of "ON/off" button to "ON" and push "Send". The displayed configuration will be sent to datalogger, received back and shown again for verification.

If there was already running a measurement with another configuration before, do not forget to initialize the datalogger. Otherwise the data of previous measurement would be wrongly converted.

7. Software

The program Mini32 works under XP and newer versions of Windows® operating systems. It supports all necessary operations for datalogger setting, data handling and file processing. It communicates with EMS devices via RS232 serial line connection or IrDA interface (a special PC cables is required).

Most of buttons, some tabs and tables are equipped with hints for better understanding its functionality.

The installation of Mini32 software includes also DLC files containing datalogger firmware of all supported hardware systems. Use them in emergency situations only, the best after consulting of manufacturer.

8. Maintenance

Besides of necessary checking of general shape of enclosure and connectors it is necessary to replace the desiccant bags. Watch the internal humidity and replace bags when the humidity approaches 90 % value.

Once per five years it is recommended to replace back-up lithium battery (CR2032). The battery is placed below the datalogger front panel on the main PC board.

9. Warranty

The product is warranted by exporter against defects in material and workmanship for a period of **three years** from the date of shipment from the company.

The product found to be defective during the warranty period will be repaired or replaced and returned freight prepaid.

The producer is not responsible for the faults originated by careless manipulation, incorrect operations, wrong applications or the destruction of seals.