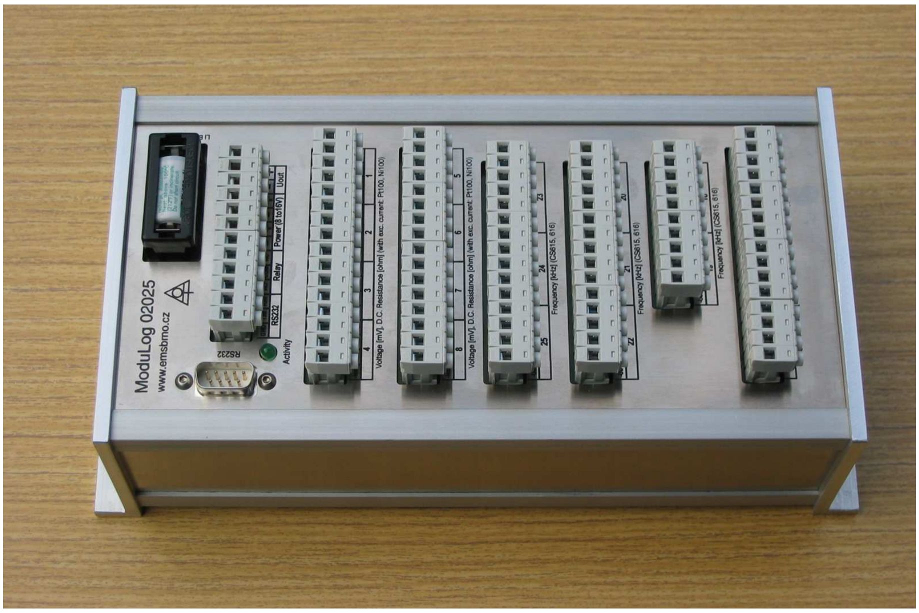
# Datalogger ModuLog




## User's Manual

October 2009

Jiří Kučera - Environmental Measuring Systems
Turistická 5
621 00 BRNO
Czech republic
Phone/fax +420 541 225 344
www.emsbrno.cz

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# 1 DATALOGGER GENERAL DESCRIPTION

It is a line of dataloggers mostly intended for specific purposes (soil measurement, meteorology). All ModuLog models combine four main input channel types which allow measurement of D.C. Voltage or resistance, A.C. Resistance, frequency and counting pulses.

Datalogger case combines duralumin frame with stainless steel sidewalls. Datalogger is supplied with D.C. voltage is range between 7 to 16 Volts, the long life Lithium-ion battery placed in front panel keeps configuration and data for 8 years at least.

## 1.1 MAIN FEATURES

- Specific configuration models
- High storage capacity up to 220,000 values
- Ready for remote access via GSM modem
- Programmable output switch
- Compact size
- Advanced Windows® software for device setting, data retrieval and processing

## 1.2 MEASURING CHANNEL TYPES

Standard input channels: (up to 36 channels altogether)

- D.C. voltage (Voltage output sensors, Temperature)
- A.C. resistance (Gypsum block, Watermark sensors)
- Frequency (Campbell Sci. CS616 soil moisture sensor)
- Counters (Rain gauge, Wind speed, Events)

## 1.3 MODELS AVAILABLE ACCORDING TO CHANNEL CONFIGURATION

| **model #** | **1036** | **1037** | **1033** | **3029** | **1027** | **2031** | **4029** |
|---|---|---|---|---|---|---|---|
| Voltage | 32 | 36 | 8 | 18 | 10 | 8 | 9 |
| A.C. Resistance | - | - | 24 | 8 | 8 | 12 | 9 |
| Frequency | - | - | - | - | 6 | 8 | 9 |
| CCSS | - | - | - | - | - | - | - |
| 16-bit counter | 3 | - | - | - | 2 | 2 | 2 |

### 1.4 SPECIFICATIONS

| | |
|---|---|
| *D.C. Voltage channels* | Differential |
| - range | ± 20 mV up to ± 2.5 V in eight ranges |
| - voltage limit | Maximum +5 Volts from GND on any input terminal |
| - accuracy | 0.03 % |
| - resolution | 16-bit |
| *A.C. Resistance channels* | Differential |
| - range | 25 kOhm |
| - accuracy | 1 % of full scale |
| - resolution | 16-bits |
| *Frequency* | 15 Hz to 100,000 kHz in eight ranges |
| - input voltage | > 0.5 V |
| - accuracy | Better than 0.1% |
| - resolution | Better than 0.1% of full scale in each range |
| *Counters* | 16-bit (65,536 counts) |
| - input type | El. Pulses (Lo< 1 Volt, Hi>4 Volts) |
| | Contact closure ($R_{threshold}$ = 1000 ohms) |
| - maximum counting frequency | Contact closure 400 Hz, el. input up to 100 kHz |
| *Memory:* | |
| - size | 500 kByte RAM, Lithium back-up battery |
| - capacity | Approx. 220,000 values |
| Measuring interval | 3 sec to 24 hrs |
| Averaging interval | 3 sec to 24 hrs |
| *Excitation* | |
| - reference voltage | 1.25 V; max.100 mA; 50 ppm temperature stability |
| - D.C. current | Exactly temperature dependent (500-650 µA); load resistance less than 400 Ohm |
| - switched supply voltage | ca 0.7 Volts less than Ub, max. load 1 A, unfused! |
| - relay switch | max. 125 V; 0.5 A; user programmable |
| Operating range | -20 to 60 deg.C |
| Size | ca 225 x 125 x 65 mm |
| Weight | ca 0.8 kg |

## 1.5 POWER SUPPLYING

Any batteries or power adapter with the voltage between 6.5 and 16 Volts can be used. The data memory is protected against data loss with a Lithium-ion back up battery which lasts ten years at least. The battery is placed in a secure holder on the datalogger front panel. Important: Its replacement *under no power supply voltage* will cause irreversible loss of data and configuration!

The power supply voltage is checked after each measurement. When the voltage is found below the lower limit (6.5 Volts), the measurement value is omitted. When such a situation occurs twice in following measurement, the datalogger operation is stopped until the rest of the day. At midnight, the measurement is resumed until the next low voltage occurrence.

Note: Any communication with PC resumes the measurement, too.

## 1.6 GROUNDING

All channels are arranged as differential ones. Maximal 5 Volts against the negative pole of power supply is allowed on each input terminal. Note also that the negative pole of power supply is internally connected with all terminals marked as "GND".

# 2 CHANNEL TYPES

ModuLog dataloggers have basically four channel types - voltage, counters, frequency and digital inputs.

## 2.1 D.C. VOLTAGE

The range of voltage channel has to be set manually during the datalogger configuration. For those gauges that are included in library, the proper sensor range is mentioned beside the gauge name (refer to Mini32 software manual). The range of user-defined sensors should be set according to the knowledge of their output characteristics. If the input signal exceeds the range, the voltage value is replaced with missing value symbol (refer to Mini32 software manual for details). Please note that the maximum voltage range from zero up to +5 Volts regarding to GND (or negative pole of external power supply) on each terminal is allowed otherwise an interference between channels will occur!

## 2.2 COUNTERS

16-bit counter means in practice that the counter capacity within the measuring interval is 65,536 pulses. This capacity should be considered when setting the measuring interval. If the number of pulses exceeds the counting capacity, the counter starts to count again from zero so the pulse number equal to counter capacity is forgotten (for instance, instead of 66,000 pulses we get just 66,000 - 65,536 = 464 pulses).

There are two kinds of inputs by counters. The first one measures number of contact closures during the measuring period and the second counts the number of electrical pulses coming on the input. Please note that when the contact is closed, small electric current passes through it what rises up the power consumption from the batteries. Therefore, the sensors using the contact output should be designed such a way that the contact is off most of the time. Also, the maximum frequency range here is limited because of noise suppressing by input circuit to 400 pulses per second (Hz).

The second counter inputs should be used for counting of electric pulses with the amplitude higher than 4 Volts. The maximal frequency that might be accepted on this input is 100 kHz. However, be aware that the maximum pulses coming within the measuring period should not exceed 65,536/$T_{meas}$ [sec]. So, in practice considering the three-second minimum interval, the maximal frequency allowed on the counting input is 21 kHz.

The output of counters as well as by the voltage channels is saved as a 2-byte number. Because of necessary rounding, two virtual ranges, **F**ast and **S**low are available.

The **F**ast one stores the pulse number in memory as an average from the measuring intervals the same way as by voltage channels (the pulses from each measuring interval are summarized and that divided by the averaging/measuring interval ratio). However, because the pulse average is stored as integer it causes a significant rounding error by small amount of pulses. On the other hand, the **F**ast range allows using the whole counter capacity (65 536 pulses) in each measuring period.

The error of the measurement low frequency pulses with **F**ast range depends on the interval ratio and the pulse number. See following example showing the worst cases:

| Averaging/measuring interval ratio = 10 | | | | | |
|---|---|---|---|---|---|
| Number of pulses coming within the **averaging** interval | 2 | 5 | 15 | 35 | 95 |
| Output value in data file [pulses per **measuring** period] | 0 | 1 | 2 | 4 | 10 |
| Right value [pulses per **measuring** period] | 0.2 | 0.5 | 1.5 | 3.5 | 9.5 |
| Error in % | 100 | 50 | 33 | 14 | 5 |

The maximal rounding error decreases with the pulse frequency and rises up with the interval ratio. So please set the **S**low range for low frequency pulse signals (tipping bucket rain gauge i.e.).

The **S**low range is completely exact because pulses are stored not as the *average* but as the *total per averaging interval* and the calculation of mean value is made in computer with high accuracy. However, the maximum pulse number in the *averaging* period cannot exceed the counter capacity (65 366 pulses). As the consequence, the maximal number of pulses allowed to come within the measuring period is reduced by interval ratio:

| Slow range | | | | | | |
|---|---|---|---|---|---|---|
| Averaging / measuring interval ratio | 1 | 2 | 5 | 10 | 20 | 50 |
| Max. pulse number allowed in measuring interval | 65536 | 32768 | 13107 | 6553 | 2376 | 1310 |

Summarized: ***Slow* range should be preferred until the expected number of pulses coming within the measuring interval does not exceed the value calculated as 65536/interval ratio. Otherwise, the *Fast* one has to be set.**

## 2.3 FREQUENCY

These channels are aimed for the measurement of frequency of an electrical signal. In contrast to counters that register pulses continuously, frequency measurement is performed only at the time of regular measurements.

The input range of measuring signal is limited by clamping diodes (bipolar transil) to ±16 Volts regarding to GND (negative supply voltage terminal). The signal input resistance behind the decoupling capacitor (68 nF) is ca 100 kohms. For proper operation the signal amplitude of 0.5 Volts is required although even lower value might be sufficient when the square wave signal is measured.

There are seven ranges of measurement that should be chosen according to the lowest measured frequency and demanded resolution. The maximum measured value is up to 100,000 Hz independently on the range.

*Note: The principal of the measurement is the evaluation of the time between the following pulses (waves). Consequently, the measurement of very low frequencies would takes a lot of time as the time period is inversely proportional to frequency. For this reason, the measurement of one channel is limited to 60 msec what corresponds to the lowest measuring value by certain range. The lower values are taken as the missing ones. Further, for better resolution by higher frequencies, the time interval of more periods is measured at the expense of lowest measured frequency. So the range should be selected according to the frequency range and demanded resolution.*

The frequency range properties are shown in following table:

| Range | Number of measured periods | Resolution better than 0.1% | Resolution better than 1% |
|---|---|---|---|
| > 15 Hz | 1 | up to 1 kHz | up to 10 kHz |
| > 30 Hz | 2 | up to 2 kHz | up to 20 kHz |
| > 60 Hz | 4 | up to 4 kHz | up to 40 kHz |
| > 120 Hz | 8 | up to 8 kHz | up to 80 kHz |
| > 240 Hz | 16 | up to 16 kHz | in full range |
| > 480 Hz | 32 | up to 32 kHz | in full range |
| > 960 Hz | 64 | up to 64 kHz | in full range |

## 2.4 CCSS CHANNEL TYPE (OBSOLETE)

This channel is made especially for connection of Campbell Consulting Soil Sensor, measuring in two steps both soil moisture (conductivity) and temperature.

These sensors are powered in groups of three sensors thus reducing the peak battery load and saving the energy. Despite of that one sensor needs seven seconds of excitation, all eight channels require only 21 seconds to complete the measurement. During this time period, the maximum excitation current reaches about 75 mA with an average of about 60 mA. When less sensors are used, they are grouped to triplets is ascending orders of channel numbers.

# 3 SENSOR EXCITATION

Some sensors need energy for their supplying or for the measurement itself. For this purpose, the datalogger contains two excitation sources - the voltage and current ones - which are activated during the measurement.

## 3.1 EXCITATION CURRENT

It is used mainly for the resistance measurement. The most common application is temperature measurement based on Pt100, Ni100. For this purpose, a temperature dependent D.C. current is used. The value of this current is directly proportional to internal datalogger temperature and it is used for its measurement.

The measuring current ranges from 500 to 650 µA and it passes through diodes connected in parallel to excitation terminals. When the measured resistance is connected between terminals, the current passes through it. The excitation terminals are connected in series what assures that the same current is passing by all connected sensors. Therefore, the perfect concourse of all connected sensors is guaranteed.

The maximum voltage drop of one diode must not exceed 350 mV in order to assure that the whole current in passing through the sensor connected in parallel to diode. Therefore, the maximum resistance should be lower than 400 ohms considering the maximum voltage drop. With respect to the maximal voltage allowed on each input terminal only limited number of excitation terminals in series can be used. Therefore, all ModuLog dataggers have more excitation section running in parallel. The excitation current of these "slave" sections is driven by self-aligning control.

## 3.2 EXCITATION VOLTAGE

### 3.2.1 REFERENCE 1.25 VOLT

The reference voltage is used for supplying of generally ratiometric sensors where the output voltage depends somehow on supply voltage. In practice: wind vane, position sensors, dendrometer increment sensors etc. The total load should not exceed 100 milliamps.

### 3.2.2 SWITCHED VOLTAGE

This voltage is usually used for supplying of sensors which do not need stabilized power supplying for operation, for example: Rotronic temperature and humidity sensors, Delta-T Theta probes, EMS33 temperature and humidity sensors, barometers etc. It can be used also as an excitation signal for switching on an external power supply for measuring systems demanding higher power.

The voltage about 0.7 Volts lower than power supply voltage appears on voltage excitation terminals when the system is running i.e. during the measuring process as well as during the communication. NOTE: The maximum current is not limited and the output is not fused!

### 3.2.3 "ENABLE" SIGNAL

All frequency channels are equipped with "enable" terminal that switches on the sensor for the necessary time period. This reduces the energy consumption for sensor supplying and also excludes the interference between simultaneously running sensors (Campbell CS615 soil moisture sensors for instance).

With respect to battery life and proper sensor operation, the "enable" signal is switched off when the power supply voltage drops bellow the certain threshold. This value can be chosen on the configuration panel according to power supply voltage range (common battery type).

As for the operation, the datalogger measures battery voltage after each frequency channel. If the low voltage is found, the last value is forgotten and the measurement of remaining channel is skipped. This way reliably excludes a wrong measurement due to low power supply voltage.

# 4 GAUGE TYPES

A group of common gauges is predefined in attached software Mini32 relevant to ModuLog line.

Refer to Mini32 software manual for more details.

# 5 TIMING OF THE MEASUREMENT

There are two different time periods that should be mentioned - measuring period and period of averaging (storing into the memory). Both time intervals usually range between 3 sec and 24 hours. Note that only the numbers as integer fragments of minutes or hours are allowed. This rule fits to easy averaging the data to larger time intervals.

Another time period, called "warm-up" time (1 to 5 seconds), can be set if some sensors need settling time higher than one hundred milliseconds for stabilizing. All these periods influence the memory capacity and the battery lifetime, too.

By individual channels, there is another "warm-up" time selectable individually for each channel up to 100 milliseconds. Datalogger waits this time to perform the measurement after sensor enable.

## 5.1 MEMORY AND STORAGE CAPACITY

The memory is organized in cycle so the oldest data are continuously overwritten with the newest ones. The memory size is 512 kbytes, its 32 kbytes part is used for storing of system variables.

The total memory capacity is slightly above 220,000 values independently on the channel type.

The maximum number of days stored in datalogger memory can be easy calculated according to simple formula

**N = 9000/(n*k)**, where

n = number of data averaging and storing within one hour

k = number of measured channels.

When measuring every ten minutes in 10 channels, the memory will keep ca 150 days of measurement.

### 5.2 BATTERY LIFETIME

The battery lifetime depends on the number of voltage or frequency channels active, on the interval of measurement and the warm-up time. The counters demand to power supply is negligible.

The exact calculation of battery duration is complicated, but a simple estimation can be done regarding to number of voltage and frequency channels supposing 100 msec necessary for one channel reading. Than, 20 channel needs about 2 sec of system powering with ca 40 mA. When measuring each minutes, the average current draw is about 2/60 * 40 = 1.3 mA. Supposing alkaline D-type mono-cells with 15,000 milliamperhours capacity, they should power the system for 15,000/1.1 = 11,250 hours what means 470 days. However, this estimation is quite rough and it should be used as preliminary only (especially when CCSS sensor are used).

## 6 PROGRAMMABLE SWITCH

The programmable output switch is aimed for timing of external systems. The typical use is switching the modem for the remote data transfer in certain time period in selected days in order to save the batteries, switching the calibration process once a day, powering a system in certain days only etc.

The switch can be basically programmed in diurnal or hourly cycle. Up to ten switching periods per unit (day, hour) can be set and activate in each unit or selected ones. Refer to Mini32 software manual for more information.

## 7 DATALOGGER COMMUNICATION

The ModuLog dataloggers do not have any display or keyboard; the datalogger setting, data downloading and viewing suppose the use of PC® computer or Palm OS handheld. Computer can be connected to the datalogger directly via enclosed null-modem cable or by remote connection (see next topic). The ninepin D-sub connector is placed on the front panel.

### 7.1 REMOTE CONNECTION

All ModuLog dataloggers and the Mini32 software are applicable for remote communication and the data transfer via modem in GSM or normal telephone network. Please be aware that the modem power consumption is generally much higher than the datalogger consumption. Therefore, the modem connection via programmable switch, which allows powering in certain time period only, is recommended.

## 8 SOFTWARE

The software package **Mini32** running under Windows® 95, 98, NT, 2000 or XP supports all necessary operations for datalogger setting, data handling and file processing. The software components are placed in the directory c:\Program Files\EMSoft\Mini32\ if not specified otherwise during the installation process. On-line help facility will guide you through particular topics.

The installation of Mini32 software includes also firmware files containing internal datalogger code of all supported hardware systems.

Refer to Mini32 user's manual for software details and other related information.

## 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.