DC8
Current measurement system

Firmware version: v2

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What can DC8 be used for

DC8 is designed for DC and AC current measurement in electric switchboards. The DC8 printed circuit board has 8 Hall effect current sensors. At the same time it has one voltage measurement input. Measured voltage is used to calculate electric power for each current channel.

The results are available on isolated serial communications port which follows the two wire RS485 signaling standard. The protocol is modbus RTU.

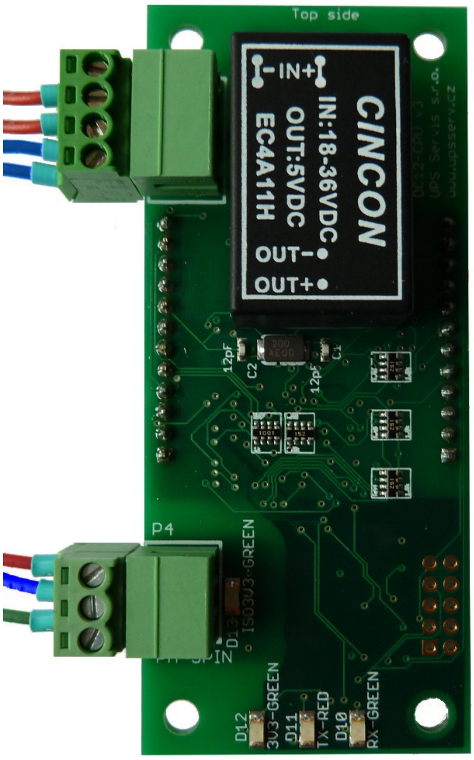
The DC8 board can be used in:

- telecom -48 VDC distribution network.
- in energy utilities and electric power stations to measure 110 VDC and 220 VDC power distribution.
- in solar power plants.

DC8 advantage:

- High measurement density: more measurements in small place.
- Measures current in both directions: output values are signed, so correct results are presented if current changes direction.
- Supports AC current measurement, RMS values are presented on output for AC current.
- Fast serial port response: less then 1 ms response time, can process more then 10 modbus transactions per second.
- Wide power supply range from 18 do 68 VDC.
- Low power: consumes 1,5 W.
- Built-in signal processing: 10 kHz sampling rate, 12 bit resolution on all channels, the board calculates average, maximum and minimum values. Min and Max values can capture very short current and voltage fluctuations.
- Isolated serial port makes the board more reliable, it will survive short circuits on measured power lines.
- Current sensors can measure current in high voltage conductors.
- Both integer and floating point values are available in seperate sets on modbus registers.
- Calibration of sensors is supported in firmware. Additional calibration allows to compensate for zero offset and sensor errors.

Instalation and wiring



DC8 consists of two PCBs one on top of the other which are fixed together with four screws using 10 mm spacers. The bigger board is a two layer PCB, it carries the sensors. The smaller board is a four layer PCB, it carries power supply, DSP and comm port electronics.

Processor board has four LED indicator lamps which are described in table below.

For external connections the processor board has two connectors: four pole connector P5 and three pole connector P4.

The four pole connector P5 (upper connector)

Pin	**Function**
1	*Power +48V*
2	*Voltage sense +(0..120V) DC*
3	*Power -48V*
4	*Voltage sense -(0..120V) DC*

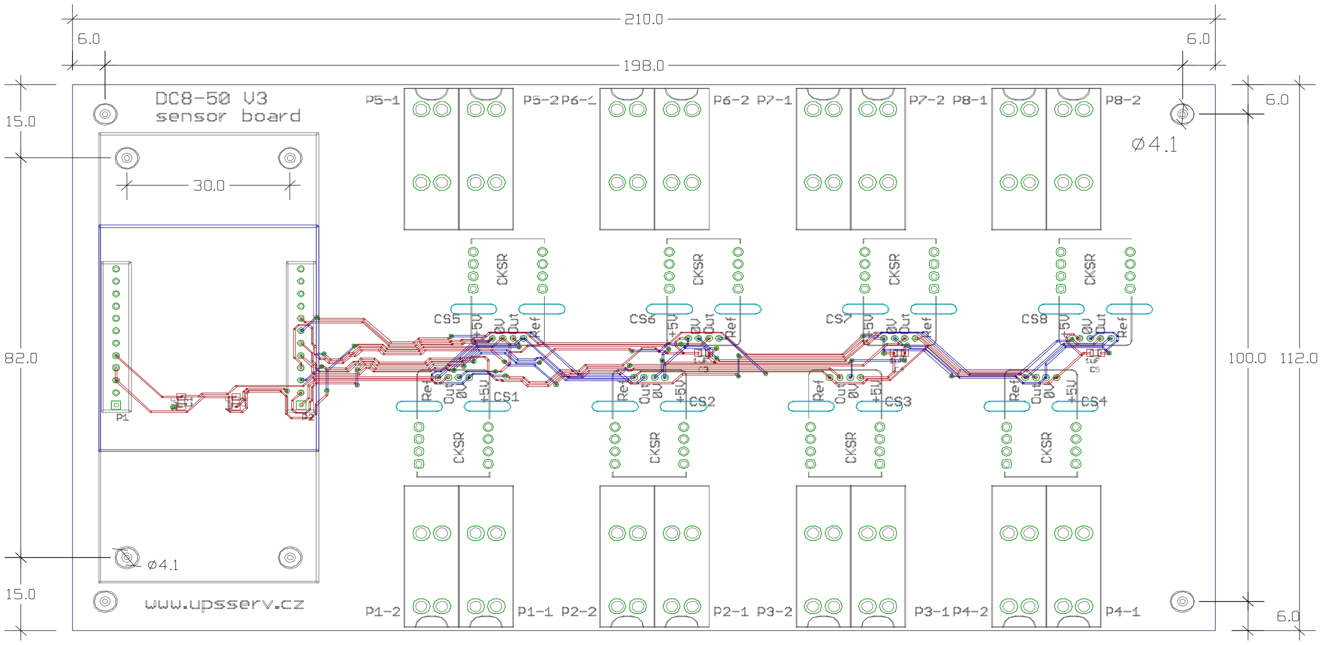
To connect power and measured input voltage use four external 0,5A fuses.

The three pole communications connector P4 (lower connector)

Pin	**Function**
1	*RS 485 A (+)*
2	*RS 485 B (-)*
3	*RS 485 ground*

All three pins are isolated from the rest of the board. The „ground" pin is provided to terminate the comm cable shield. By connecting the shield to pin 3, the shiled is not grounded, use seperate ground wire if grounding of this end of shiled is required. The communications bus shiled should be grounded only on one place, see RS485 wiring rules.

Board dimensions



DC8 board has six Ø4,1 mm mounting holes. The board can be mounted on metal base plate or on switchboard bottom using six screws and spacers. A minimum 5 mm space should be ensured from board to mounting surface, standard nuts can be used as spacers. Mounting plate or switchboard bottom should have holes for measured power cables.

Indicator lamps on processor board

There are four LED indicators on processor board:

ISO3V3	Isolated power for communications port (green)
3V3	„I/O power" power supply (green). This power supply is derived from main 5V power for sensors, so if this lamp is ON, then +5V power supply is also OK.
TXD	Transmit indicator (red). This lamp indicates transmission on serial port.
RDX	Receive indicator (green). This LED blinks on every activity on communications bus.

Technical specifications

P o w e r s u p p l y	
Power supply range	*18-36 VDC*
Power consumption	*1,5W*
Protection	*Built-in overvoltage protection (transil), upstream fuse 0,5A recommended*
EMI	*built-in LC filter*
C u r r e n t m e a s u r e m e n t	
Number of channels	*8*
Range	*-10..+10, -25..+25 or -50..+50A (depends on sensor type)*
Max conductor size	*external Ø 22 mm*
Accuracy	*1% of range*
Numeric resolution	*0,1% of range*
Max overload	*10x range*
V o l t a g e m e a s u r e m e n t	
Number of channels	*1*
Range	*0-120VDC*
Accuracy	*0,5% of range*
Max overload	*-200 VDC .. +200 VDC*
Input impedance	*99 kOhm*
C o m m u n i c a t i o n s p o r t	
Physical interface	*two wire RS485*
Speed	*9600, 19200, 38400 or 57600 bps, default setting is **19200.** Other port speeds are supported up to 115200 bps, but we recommend to use the default setting.*
Port settings[1]	*1 start bit, 8 bit data, even parity, 1 stop bit. These settings are recommended in modbus RTU protocol definition. Other settings are also supported.*
Protocol	*Modbus RTU according to V1.02 published in 2006*

1 Port speed and settings can be configured, see configuration parameters. Default settings follow modbus RTU specification.

Reading the measurements

Modbus RTU protocol is used to read measured values. Two wire bus is used to connect multiple current meters or other modbus devices to modbus master.

Default settings of DC8 board are in compliance with newest modbus standard. Modbus protocol definitions and bus wiring rules are all well documented on www.modbus.org, so we are not duplicating this information in this manual.

For correct modbus operation it is essential to use correct shielded cable, to terminate the bus with terminating resistors. Please read modbus wiring rules on www.modbus.org.

Each communications bus must be equipped with at least one overvoltage protection device. If the bus is longer then 50 meters, we recommend to install overvoltage protection on both ends of the bus. One of manufactures of suitable overvoltage protection devices in Czech republic is Saltek s.r.o., device type is DM-006/1 R DJ.

According to recommended modbus wiring rules, communications bus must be earthed (connected to PE) strictly in one point. Important: pin 3 on DC8 communications port is named „RS485 ground". This pin is NOT grounded, this pin is connected to isolated power supply „minus" of the comm port. Comm port power supply is galvanically isolated form all other circuits of DC8 as well as from 48VDC power supply.

Measurements modes

„Mode" parameter is used to select measurement modes. There are two modes:

- in DC mode voltage and current measurements are calculated as mean, max and min values from primary samples. Mean values are arithmetic mean calculated from circular buffer of samples. In DC mode, current values can be positive or negative.
- in AC mode, we first calculate RMS values from the circular sample buffer. Then min and max values are calculated form RMS values. In AC mode, all current values are always positive.

Supported data formats

DC8 suports three number formats: UINT16, SINT16 and FLOAT32. FLOAT32 is not exactly standard format for modbus, different variations of byte orders are possible and we support only one. So if our FLOAT32 is not readable correctly in your application, please use integer formats. All measurement information is available in both integer and floating point formats at the same time. To improve resolution, multipliers are used with integer values, multipliers are documented in table heading for each table.

Current average values (A), FLOAT32

Addr	***Type***	***Description***
40001	*FLOAT32*	*I1 avg*
40003	*FLOAT32*	*I2 avg*
40005	*FLOAT32*	*I3 avg*
40007	*FLOAT32*	*I4 avg*
40009	*FLOAT32*	*I5 avg*
40011	*FLOAT32*	*I6 avg*
40013	*FLOAT32*	*I7 avg*
40015	*FLOAT32*	*I8 avg*
40017	*FLOAT32*	*I9 avg*
40019	*FLOAT32*	*I10 avg*
40021	*FLOAT32*	*I11 avg*
40023	*FLOAT32*	*I12 avg*

Current maximum values (A), FLOAT32

Maximum values are automatically set to zero after each reading, so each time we get maximum values that occured between polls.

Addr	***Type***	***Description***
40025	*FLOAT32*	*I1 max*
40027	*FLOAT32*	*I2 max*
40029	*FLOAT32*	*I3 max*
40031	*FLOAT32*	*I4 max*
40033	*FLOAT32*	*I5 max*
40035	*FLOAT32*	*I6 max*
40037	*FLOAT32*	*I7 max*
40039	*FLOAT32*	*I8 max*
40041	*FLOAT32*	*I9 max*
40043	*FLOAT32*	*I10 max*
40045	*FLOAT32*	*I11 max*
40047	*FLOAT32*	*I12 max*

Current minimum values (A), FLOAT32

After each reading, minimum values are set to average values, so each reading gives minimum values that occured between polls.

A d d r	*T y p e*	*D e s c r i p t i o n*
40049	*FLOAT32*	*I1 min*
40051	*FLOAT32*	*I2 min*
40053	*FLOAT32*	*I3 min*
40055	*FLOAT32*	*I4 min*
40057	*FLOAT32*	*I5 min*
40059	*FLOAT32*	*I6 min*
40061	*FLOAT32*	*I7 min*
40063	*FLOAT32*	*I8 min*
40065	*FLOAT32*	*I9 min*
40067	*FLOAT32*	*I10 min*
40069	*FLOAT32*	*I11 min*
40071	*FLOAT32*	*I12 min*

Power average values (kW), FLOAT32

A d d r	*T y p e*	*D e s c r i p t i o n*
40073	*FLOAT32*	*P1 avg*
40075	*FLOAT32*	*P2 avg*
40077	*FLOAT32*	*P3 avg*
40079	*FLOAT32*	*P4 avg*
40081	*FLOAT32*	*P5 avg*
40083	*FLOAT32*	*P6 avg*
40085	*FLOAT32*	*P7 avg*
40087	*FLOAT32*	*P8 avg*
40089	*FLOAT32*	*P9 avg*
40091	*FLOAT32*	*P10 avg*
40093	*FLOAT32*	*P11 avg*
40095	*FLOAT32*	*P12 avg*

Voltage measurements (V), FLOAT32

A d d r	*T y p e*	*D e s c r i p t i o n*
40097	*FLOAT32*	*V avg*
40099	*FLOAT32*	*V max*
40101	*FLOAT32*	*V min*

Current average (A), SINT16 x10

Addr	***Type***	***Description***
40201	*SINT16*	*I1 avg*
40202	*SINT16*	*I2 avg*
40203	*SINT16*	*I3 avg*
40204	*SINT16*	*I4 avg*
40205	*SINT16*	*I5 avg*
40206	*SINT16*	*I6 avg*
40207	*SINT16*	*I7 avg*
40208	*SINT16*	*I8 avg*
40209	*SINT16*	*I9 avg*
40210	*SINT16*	*I10 avg*
40211	*SINT16*	*I11 avg*
40212	*SINT16*	*I12 avg*

Current maximum values (A), SINT16 x10

Maximum values are automatically set to zero after each reading, so each time we get maximum values that occured between polls.

Addr	***Type***	***Description***
40213	*SINT16*	*I1 max*
40214	*SINT16*	*I2 max*
40215	*SINT16*	*I3 max*
40216	*SINT16*	*I4 max*
40217	*SINT16*	*I5 max*
40218	*SINT16*	*I6 max*
40219	*SINT16*	*I7 max*
40220	*SINT16*	*I8 max*
40221	*SINT16*	*I9 max*
40222	*SINT16*	*I10 max*
40223	*SINT16*	*I11 max*
40224	*SINT16*	*I12 max*

Current minimum values (A), SINT16 x10

After each reading, minimum values are set to average values, so each reading gives minimum values that occured between polls.

A d d r	***T y p e***	***D e s c r i p t i o n***
40225	*SINT16*	*I1 min*
40226	*SINT16*	*I2 min*
40227	*SINT16*	*I3 min*
40228	*SINT16*	*I4 min*
40229	*SINT16*	*I5 min*
40230	*SINT16*	*I6 min*
40231	*SINT16*	*I7 min*
40232	*SINT16*	*I8 min*
40233	*SINT16*	*I9 min*
40234	*SINT16*	*I10 min*
40235	*SINT16*	*I11 min*
40236	*SINT16*	*I12 min*

Power average values (kW), SINT16 x100

A d d r	***T y p e***	***D e s c r i p t i o n***
40237	*SINT16*	*P1 avg*
40238	*SINT16*	*P2 avg*
40239	*SINT16*	*P3 avg*
40240	*SINT16*	*P4 avg*
40241	*SINT16*	*P5 avg*
40242	*SINT16*	*P6 avg*
40243	*SINT16*	*P7 avg*
40244	*SINT16*	*P8 avg*
40245	*SINT16*	*P9 avg*
40246	*SINT16*	*P10 avg*
40247	*SINT16*	*P11 avg*
40248	*SINT16*	*P12 avg*

Voltage measurement (V), SINT16 x100

A d d r	***T y p***	***P o p i s***
40249	*SINT16*	*V avg*
40250	*SINT16*	*V max*
40251	*SINT16*	*V min*

Setup and calibration

Calibration is an advanced topic. In most cases users will not need no calibration, but in case you need calibration, make sure you call our support for further guidance.

Supported modbus commands for setup and calibration

Setup and calibration procedures support only a limited set of valid modbus commands. Generally, for distinct parameters like „port speed‟ or „unit id‟ (aka „bus address‟), we only support „read single register‟ and „write single register‟ commands. So you have to set these values one by one.

For array parameters like current sensor ratings and for current sensor calibration, we only support „write multiple registers‟ and „read multiple registers‟ commands with starting address corresponding to the first sensor and with number of registers exactly 12. For example, if we want to set the range of all sensors on the board to 50, we have to issue „write multiple registers‟ command with starting address of 40911 and number of registers 12. All other variations of write command will fail with modbus exception code 1 meaning „illegal function‟.

Serial port settings

On start-up the processor always starts with default port settings and with address set to 0. After 10 seconds the port settings and address are changed to configured values stored in non-volatile flash memory.

In case we have no contact with DC8, we can connect just one board to the bus, switch ON the power supply and we have 10 seconds to read or change communications settings as required.

Calibration procedure

Calibration is optional procedure to improve measurement accuracy and eliminate possible zero offset of the current sensors. Without calibration DC8 measures to 1% accuracy which is enough for most applications.

Calibration is supported in software with two steps:

- Sensor offset calibration:
    1. Ensure there is no current flowing thought sensors.
    2. Write the „magic number‟ to specified register. Zero offsets for each sensor will be calculated and saved to non-volatile memory.
- Correction coefficient calibration:
    1. Run known current through sensor or multiple sensors. Be sure the current is big enough, at least 10% of sensor rating or more. Calibrating the sensors with small current will actually reduce the measurement accuracy.
    2. Program the value of this known or measured current in Ampers to

write-only calibration register(s). The calibration coefficients will be automatically calculated and stored to non-volatile memory.

Both offset values and calibration coefficients resulting from calibration are available in read only registers for documentation purposes, someone may want them to be printed on calibration protocol. Offset values are signed integer values in „A/D converter counts", they are added to A/D conversion results to correct sensor offset. Default offset values are zero. Correction coefficients are floating point numbers used as multiplier when converting A/D result to Amperes. Default correction coefficients value is one.

Configuration parameters

A d d r	***T y p e***	***D e s c r i p t i o n***
40901	*UINT16*	*Unit ID, address on the bus, range 1 to 247*
40902	*UINT16*	*Port speed, 9600, 19200 (default), 38400 or 57600*
40903	*UINT16*	*0 = no parity, 1 = odd parity, 2 = even (default)*
40904	*UINT16*	*1 = one stop bit (default), 2 = two stop bits*
40905	*UINT16*	*Mode: 0 = DC (default), 1 = AC*
40906	*UINT16*	*Delay 1: delay (usec) before transmit Tx (Default 1800)*
40907	*UINT16*	*Delay 2: delay (usec) after transmit Tx (Default 1800)*

Offset calibration

A d d r	***T y p e***	***D e s c r i p t i o n***
40908	*UINT16*	*Magic number: writing the value of 7294 to this register triggers automatic offset calculation for all current sensors, offsets are then stored in non-volatile memory.*
40909	*UINT16*	*Magic number: writing the value of 1278 to this register triggers board reset to factory defaults.*
40910	*UINT16*	*Current configuration: 0 = configuration, 1 = default*

Sensor ranges

DC8 can have three types of sensors installed, the part numbers are CKSR 10-NP , CKSR 25-NP, and CKSR 50-NP. Current range of sensors is coded into part number. Theoretically, sensors with different ranges can be mounted on single DC8 board. So we can set the sensor range individually for each sensor.

A d d r	***T y p e***	***D e s c r i p t i o n***
40911	*SINT16*	*Range 1 - range of sensor 1 (10, 25 or 50)*
40912	*SINT16*	*Range 2*

Addr	Type	Description
40913	SINT16	Range 3
40914	SINT16	Range 4
40915	SINT16	Range 5
40916	SINT16	Range 6
40917	SINT16	Range 7
40918	SINT16	Range 8
40919	SINT16	Range 9
40920	SINT16	Range 10
40921	SINT16	Range 11
40922	SINT16	Range 12

Offsets (sensor reading deviation with zero current) (read only)

Addr	Type	Description
40923	SINT16	Offset 1
40924	SINT16	Offset 2
40925	SINT16	Offset 3
40926	SINT16	Offset 4
40927	SINT16	Offset 5
40928	SINT16	Offset 6
40929	SINT16	Offset 7
40930	SINT16	Offset 8
40931	SINT16	Offset 9
40932	SINT16	Offset 10
40933	SINT16	Offset 11
40934	SINT16	Offset 12

Correction coefficients (read only)

Addr	Typ	Popis
40935	FLOAT32	K 1
40937	FLOAT32	K 2
40939	FLOAT32	K 3
40941	FLOAT32	K 4
40943	FLOAT32	K 5
40945	FLOAT32	K 6

40947	*FLOAT32*	*K 7*
40949	*FLOAT32*	*K 8*
40951	*FLOAT32*	*K 9*
40953	*FLOAT32*	*K 10*
40955	*FLOAT32*	*K 11*
40957	*FLOAT32*	*K 12*

Known current values for sensor calibration

Writing the known or measured current value in Amperes for each sensor calibration coefficients will be calculated and stored to non-volatile memory. These coefficients are used to calculate the measured current values.

Addr	***Type***	***Description***
40959	*FLOAT32*	*I1 cal: measured current value for I1*
40961	*FLOAT32*	*I2 cal*
40963	*FLOAT32*	*I3 cal*
40965	*FLOAT32*	*I4 cal*
40967	*FLOAT32*	*I5 cal*
40969	*FLOAT32*	*I6 cal*
40971	*FLOAT32*	*I7 cal*
40973	*FLOAT32*	*I8 cal*
40975	*FLOAT32*	*I9 cal*
40977	*FLOAT32*	*I10 cal*
40979	*FLOAT32*	*I11 cal*
40981	*FLOAT32*	*I12 cal*

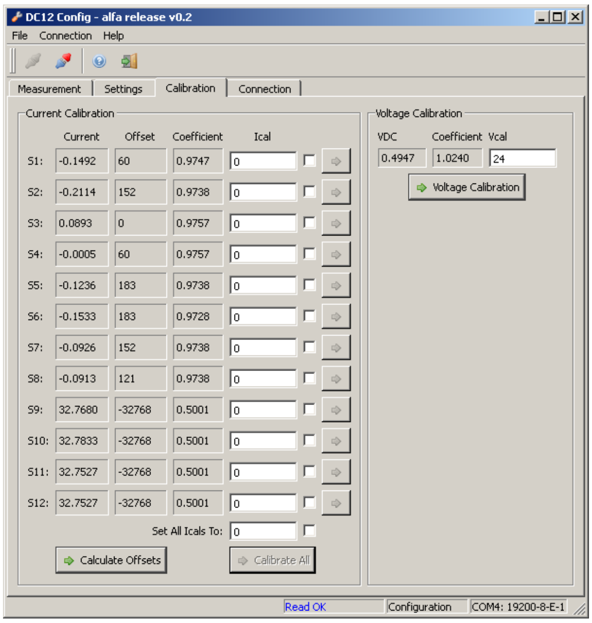
Voltage calibration value (read only)

Addr	***Type***	***Description***
40983	*FLOAT32*	*Kcal – correction coefficient for voltage measurement.*

Known or measured voltage for calibration (write only)

Addr	***Type***	***Description***
40985	*FLOAT32*	*Writing known voltage to this register will trigger Vcal calibration coefficient calculation. Result is then saved in non-volatile memory.*

Application DC12config



To verify board functionality and measurement calibration is available configuration program DC12config. The program is simple and easy to use, however assumes some basic knowledge of RS485 Modbus Protocol. Particular attention should be paid the tab calibration. Faulty calibration results in incorrect measurements.

Recommended calibration procedure:

1. Use the „Connect Board“ button to connect the board.
2. By pressing „Calculate offsets“ without current, calibrate zeros.
3. After pressing the "Calibrate offsets" the board resets and runs 10 seconds in the default settings, then it reads the new configuration. Therefore, it is needed after each change wait 10 seconds.
4. Check whether we have good zeros on all sensors. This calibration (without current) can be arbitrarily repeated.
5. Appropriate power supply (at least half of nominal sensor current) and ampermeter is needed. The power supply must be sufficiently stable. The sensors in series can be calibrated together. For the calibration of all sensors at once is the input box and button "Calibrate All" at the bottom of the screen. In the input box, enter the actual measured current and press the button. The calibration coefficient will be automatically calculated and stored in flash memory. After the calibration should be once again wait 10 seconds.
6. Po kalibraci je třeba opět počkat 10 sekund.
7. Sensors can be also calibrated separately. To use the input box and click on the button on selected sensor.

DC12config application is free to dowvload at the following address:
http://www.upsserv.cz/download/dc12/dc12config.zip

Package contents

The following contents should be found in your box:

- Main (bigger) board whit sensors
- Processor (smaller) board with plastic cover
- User manual