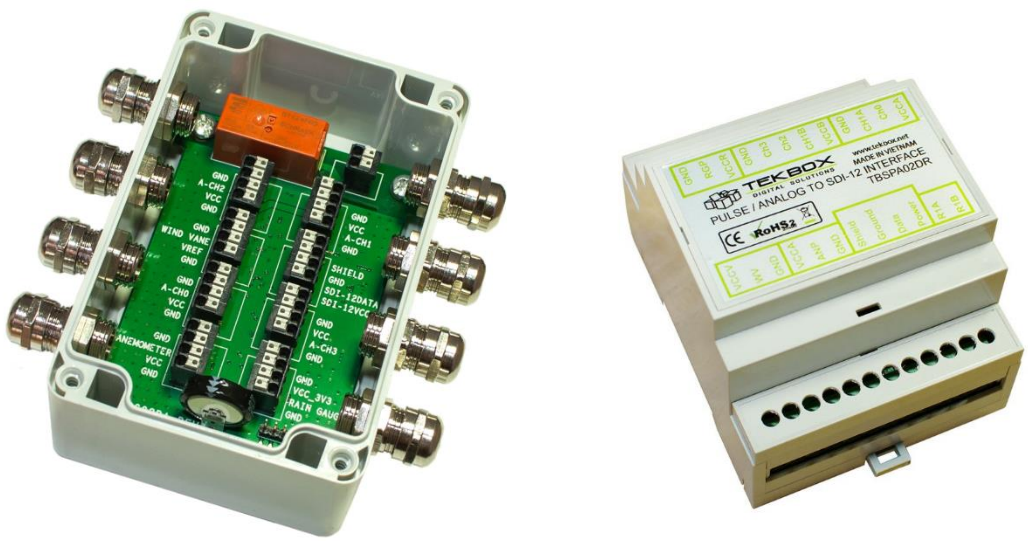
SDI-12 Pulse / Analog Interface

The TBS02PA is a SDI-12 interface board for the connection of a rain gauge, an anemometer and a wind vane. Furthermore it provides 3 general purpose analog inputs with a range of 0-1V, 0-2,5V, 0-5V and a 4…20mA current input. The ADC provides a resolution of 12 Bit.
The pulse count inputs are supported by a real time clock circuit, buffered with a super-capacitor. It is capable of holding the time for more than 6 month after the last measurement.
The interface board supports both passive and active anemometers with pulse outputs. The 12V supply lines for attached sensors are only switched on during the measurement in order to minimize current consumption.
The TBS02PA is available in two housing variants. One variant comes in an off shelf IP67 housing from Fibox. The other variant comes in a DIN Rail housing.



TBSPA02 SDI-12 Pulse / Analog Interface

Features

- dedicated pulse input for a rain gauge
- dedicated pulse input for an anemometer
- advanced anemometer features (averaging and calculation of minimum and maximum wind speed over a configurable logging period
- dedicated analog wind vane input
- analog input, 0-1V, 12 bit
- analog input, 0-2.5V, 12 bit
- analog input, 0-0.25V/0.5V/5V, 12 bit
- current input, 4-20mA, 12 bit
- SDI-12 controllable latching relay with read back capability and timer functionality
- switched sensor supply output
- Precision reference
- Low noise/low drift chopper amplifiers
- SDI-12 Standard V1.3
- Plug and Play
- 6 - 16V supply voltage
- DIN RAIL variant
- Fibox housing variant
- Operating Temperature Range: - 40°C … + 85°C
- Excellent price-performance ratio

Target Applications

- SDI-12 Sensor Networks

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1 Introduction

The TBSPA02 is a versatile SDI-12 interface box, suitable to connect rain gauges and anemometers with pulse output, wind vanes with analog or potentiometer output and analog sensors with voltage or current output.
To extend its scope of application, the TBSPA02 contains a latching relay which can be coupled to an internal temperature sensor to switch the heating for wind vane / anemometer or which can be used to control irrigation. The relays can be coupled with an on board RTC timer. The RTC is also used to calculate accumulated rainfall.

1.1 Measurement

The TBS02PA offers 8 input channels:

Anemometer	pulse input, momentary wind speed or average, minimum and maximum wind speed over a configurable logging period
Rain gauge	pulse input
Wind vane	2,5V analog input / potentiometer input
Analog Channel 0	0V ... 1V
Analog Channel 1	0V ... 2.5V
Analog Channel 2	0V ... 0.25V / 0.5V/ 0 … 5V; configurable with extended SDI-12 command
Analog Channel 3	0 (4mA) ... 20mA

Additional features:
Latching relay output with read back capability
Dual channel RTC buffered with super capacitor
On board temperature sensor
Reference voltage: 2.5V, +/-2mV, 5ppm/°C
ADC Resolution: 12 Bit
Low noise/low drift chopper amplifiers

1.2 Product Features

- Measurement of input channels with individual M-Commands
- Setting of the response time with Extended SDI-12 Command
- The measurement result of each channel can be independently scaled with a third order polynomial using Extended SDI-12 Commands
- On board temperature sensor
- Dual channel RTC
- Low noise/low drift chopper amplifiers
- Precision reference
- Input protection
- Dimensions: 80mm x 120mm x 57mm
- Mounted into IP67 housing of FIBOX, model PC081206 or DIN-rail housing
- Operating temperature range: -40 … +85°C

1.3 Calibration

An offset or gain error of the analog system (sensor + TBS02PA analogue frontend) can be compensated using the scaling capability of the TBS02PA.

1.4 Installation

The TBS02PA is compatible with any data logger or remote telemetry unit with SDI-12 interface. Refer to the data logger or RTU manual and to chapter 2 of this datasheet.

1.5 SDI-12

SDI-12 is a standard for interfacing data recorders with microprocessor-based sensors. SDI-12 stands for serial/digital interface at 1200 baud. It can connect multiple sensors with a single data recorder on one cable. It supports up to 60 meter cable between a sensor and a data logger.

The SDI-12 standard is prepared by

SDI-12 Support Group
(Technical Committee)
165 East 500 South
River Heights, Utah
435-752-4200
435-752-1691 (FAX)
http://www.sdi-12.org

The latest standard is version V1.3 which dates from July 18th, 2005. The standard is available on the website of the SDI-12 Support Group.

More information on SDI-12 is presented in chapter 3.

2 Application Examples

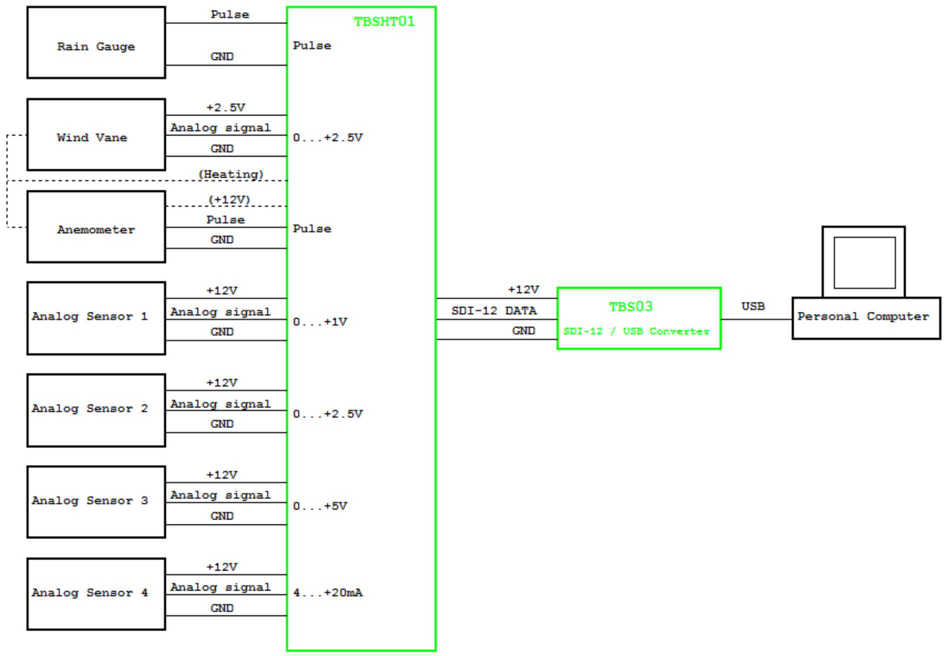

Figure 1 – Sensors connected to TBS02PA and to TBS03 SDI-12 to USB converter; setup for controlling / testing sensors and for PC based data recording

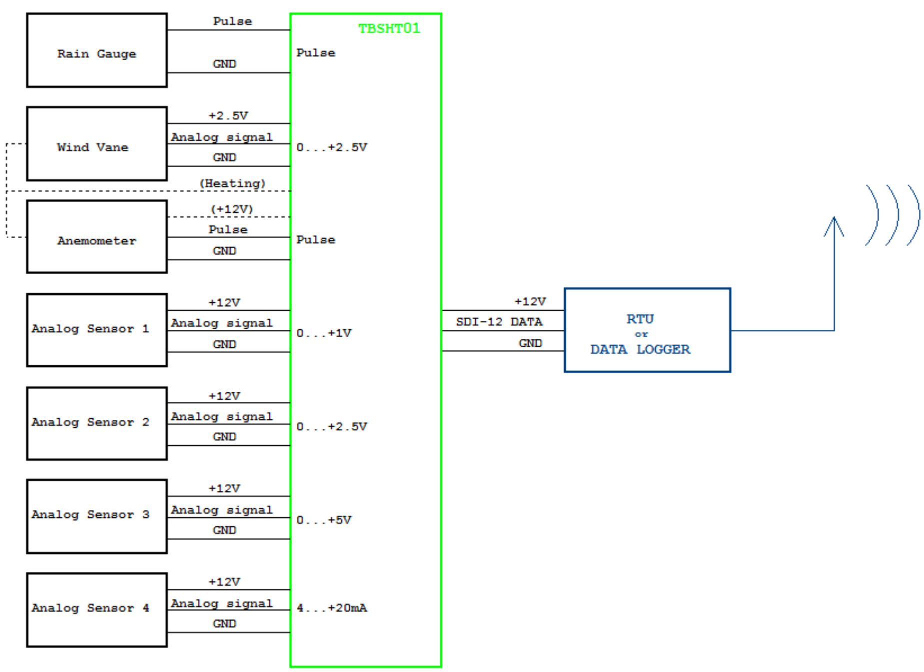

Figure 2 – Analogue sensors connected to TBS02PA and to Remote Telemetry Unit or Data Recorder

3 Hardware Description

3.1 FIBOX variant, board overview

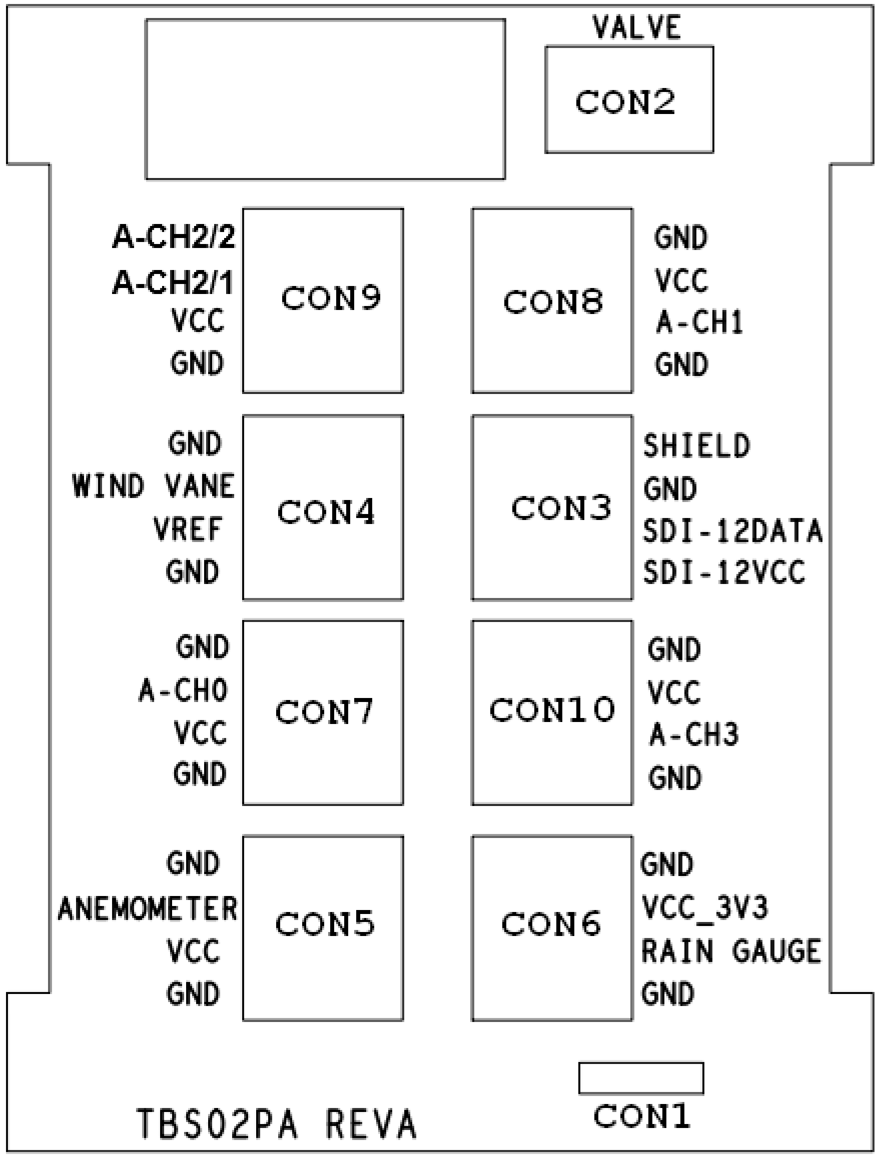

Figure 3 – Fibox Variant: Connector Positions

The TBAB02 is based on a sensor front end with input over-voltage protection, pulse inputs, chopper amplified analog inputs, a 12 bit ADC and a precision voltage reference. A microcontroller controls the analog section, power management and the SDI-12 communication.

3.2 Connections

4 Pin terminal blocks:

CON3 – SDI-12 Interface

Shield: connect to the shield of the SDI-12 cable or leave it unconnected
Ground: connect to the GND wire of the SDI-12 cable
SDI-12 data: connect to the data wire of the SDI-12 cable
6-12V supply: connect to the positive supply voltage wire of the SDI-12 cable

CON7 – Analog input channel 0; 0…1V input voltage range; 6-12V sensor supply voltage output
CON8 – Analog input channel 1; 0…2.5V input voltage range; 6-12V sensor supply voltage output
CON9 – Analog input channel 2/1; 0…5V input voltage range; 6-12V sensor supply voltage output
CON9 – Analog input channel 2/2; 0…0.25V/0.5V input voltage range; 6-12V sensor supply voltage output
CON10 – Analog input channel 3; 0(4)…20mA input current range; 6-12V sensor supply voltage output

GND: connect to sensor GND
GND: connect to cable shield
Analog input: connect to the ratio metric voltage or current output of the sensor
VCC: connect to the sensor supply input; the output voltage is equivalent to the SDI-12 supply voltage and gets switched on during an SDI-12 measurement

CON5 – Anemometer terminal block; pulse input; connectivity for active (pulse output) and passive (reed switch) anemometers

GND: connect to sensor GND
GND: connect to cable shield
Anemometer: connect to the pulse output of the sensor (active anemometer); connect the reed switch of passive anemometers between this terminal and VCC
VCC: supply terminal for active anemometers; the output voltage is equivalent to the SDI-12 supply voltage and gets switched on during an SDI-12 measurement; connectivity for the reed switch

CON4 – Wind vane terminal block; analog input; connectivity for potentiometer based wind vanes

GND: connect the low side of the potentiometer to this terminal

GND: connect to cable shield

Wind vane: connect the wiper of the potentiometer to this terminal

VCC: 2.5V buffered reference voltage output; connect the high side of the potentiometer to this terminal

CON6 – Rain Gauge input channel; pulse input; connectivity for reed switch based rain gauges

GND: connect to sensor GND

GND: connect to cable shield

Rain Gauge: connect the reed switch of the rain gauge between this terminal and VCC

VCC: 3.3V supply terminal; connectivity for the reed switch; the TBS02PA needs to be powered continuously, if a rain gauge is connected. The rain gauge will be in sleep mode most of the time. A pulse of the rain gauge will generate an interrupt and briefly wake up the controller.

CON2 – latching relay switch terminals; relay: Schrack RT424F05: 250V,max. 300V/8A.

Datasheet: http://www.tekbox.net/_downloads/Relay_ENG_DS_RT2_bistable_0910.pdf

CON1 – do not connect; for factory test only

3.3 DIN-RAIL variant, board overview

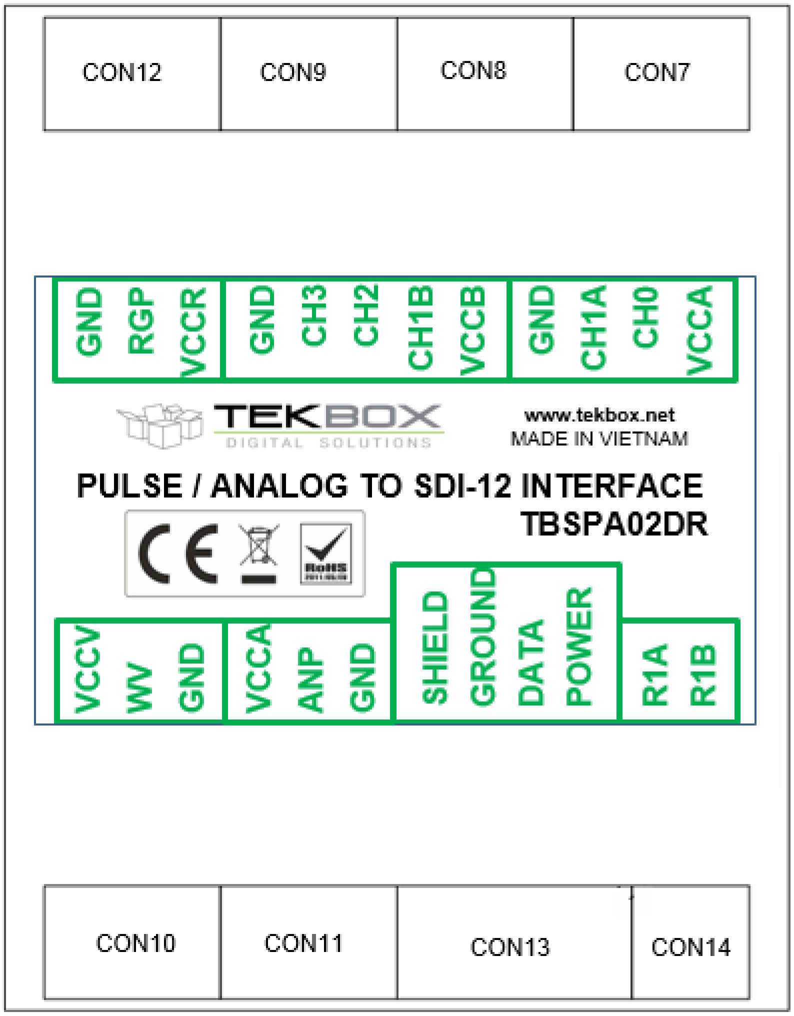

Figure 4 – Fibox Variant: Connector Positions

CON7, CON8, CON9 – shared, analog input channels

CH0: Analog input channel 0; 0…1V input voltage range

CH1A: Refer to commands concerning CH1; Analog input channel 1; 0…2.5V input voltage range

CH1B: Refer to commands concerning CH2; Analog input channel 2; 0…0.25V/0.5V input range

CH2: Analog input channel 2; 0…5V input voltage range

CH3: Analog input channel 3; 0(4)…20mA input current range

VCCA: switched supply voltage for analog CH0, CH1A; 6….12V, equivalent to SDI-12 supply voltage

VCCB: switched supply voltage for analog CH1B, CH2, CH3; 6….12V, equivalent to SDI-12 supply

CON10 – Wind vane terminal block; analog input; connectivity for potentiometer based wind vanes

GND: connect the low side of the potentiometer to this terminal, connect to cable shield if available

WV: connect the wiper of the potentiometer to this terminal

VCCV: 2.5V buffered reference voltage output; connect the high side of the potentiometer to this terminal

CON11 – Anemometer terminal block; pulse input; connectivity for active (pulse output) and passive (reed switch) anemometers

GND: connect to sensor GND, connect to cable shield if available

ANP: connect to the pulse output of the sensor (active anemometer); connect the reed switch of passive anemometers between this terminal and VCC

VCCA: supply terminal for active anemometers; the output voltage is equivalent to the SDI-12 supply voltage and gets switched on during an SDI-12 measurement; connectivity for the reed switch

CON12 – Rain Gauge input channel; pulse input; connectivity for reed switch based rain gauges

GND: connect to sensor GND and cable shield if available

RGP: connect the reed switch of the rain gauge between this terminal and VCC

VCCR: 3.3V supply terminal; connectivity for the reed switch; the TBS02PA needs to be powered continuously, if a rain gauge is connected. The rain gauge will be in sleep mode most of the time. A pulse of the rain gauge will generate an interrupt and briefly wake up the controller.

CON13 – SDI-12 Interface

Shield: connect to the shield of the SDI-12 cable or leave it unconnected

Ground: connect to the GND wire of the SDI-12 cable

Data: connect to the data wire of the SDI-12 cable

Power: connect to the positive supply voltage wire of the SDI-12 cable; 6V..16V, nominal 12V

CON14 – Relay Interface

R1A: Relay1, contact A

R1B: Relay1, contact B

4 Anemometer input

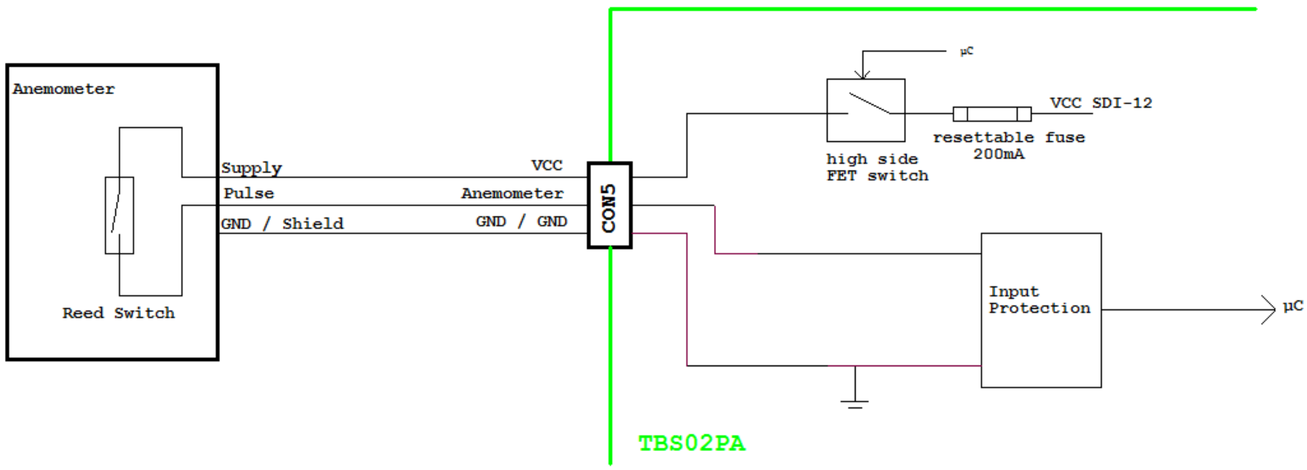

Figure 5 – reed switch based anemometer; connection to TBS02PA

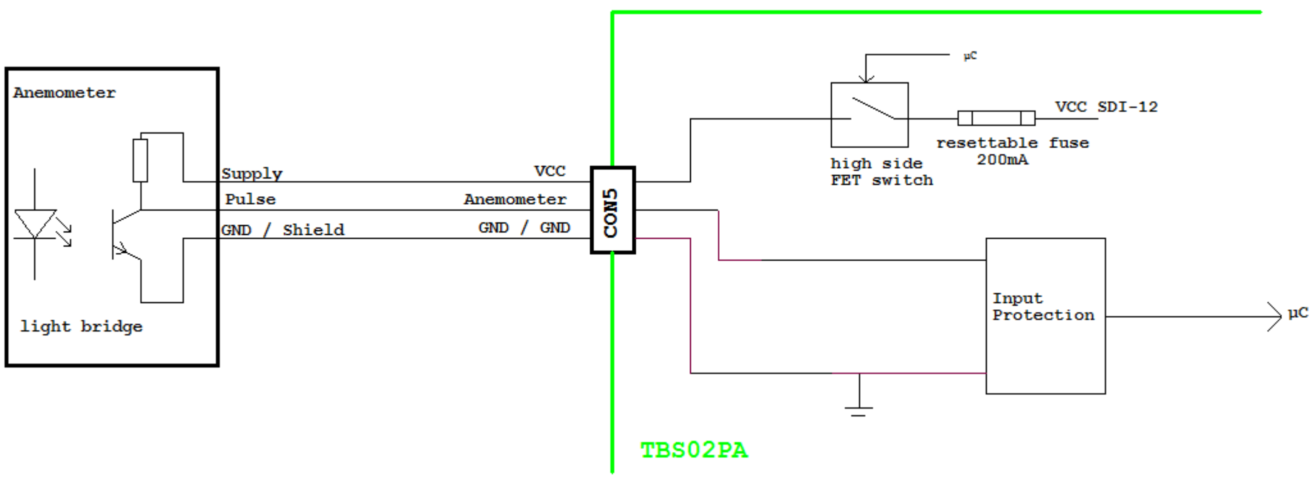

Figure 6 – light barrier based anemometer; connection to TBS02PA

The anemometer input can handle reed switch based anemometers or light barrier / hall sensor based anemometers which require 12V supply voltage and which deliver pulses at the output. The pulse amplitude can be in the range of 3V...12V and even higher.

Modern commercial anemometers have a linear measurement range of 0.3 to 75m/s with a measurement uncertainty in the range of 1 to 2%. Linear measurement range refers to the function of wind speed versus angular speed or RPM of the rotor.

It is necessary to know the relation between pulse rate and wind speed. This may be given in various units, depending on the manufacturer and should be specified in the manual of the anemometer.

The anemometer input can either measure momentary wind speed (simple mode), or measure average wind speed, maximum wind speed and minimum wind speed over a configurable logging period (advanced mode).

In advanced mode, wind speed is measured every 3 seconds. The measurement valuess are then averaged over a configurable period which must be a multiple of 3 seconds, up to a maximum of 60 seconds. The averaged values are then collected over a configurable logging period. At the end of the logging period, average wind speed, minimum- and maximum windspeed of the logging period is calculated and stored. Upon a measurement command, the results of the latest, completed logging period will be delivered.
The anemometer must be continuously powered when it is operated in advanced mode.

aM6!	Start Measurement of wind speed	A0061<CR><LF> Delay (006) in seconds and number of values (1)
aMC6!	Additional Measurement and request CRC Measures wind speed and calculates CRC	A0061<CR><LF> Delay (006) in seconds and number of values (1)
aC6!	Start Concurrent Measurement Concurrent measurement of wind speed	A0061<CR><LF> Delay (006) in seconds and number of values (1)
aCC6!	Start Concurrent Measurement and request CRC Concurrent measurement of wind speed and CRC measurement	A0061<CR><LF> Delay (006) in seconds and number of values (1)
aD0!	Get Measurement Result The result is five digits with the decimal point at any position. The unit depends on the scaling factor	a+sss.ss<CR><LF>
aXSASF,sn.nnnnnnn!	Set the scaling factor The scaling factor is seven digits with the decimal point at any position. The scaling factor is a multiplicator applied to the number of pulses measured during a 5 second sampling period. It is used to convert the measured number of pulses into wind speed. See examples for calculating the scaling factor below. The default scaling factor is 0.2	aX_ok<CR><LF>
aXGASF!	Query the scaling factor	a+sn.nnnnnn <CR ><LF>
aXSAMm!	Set mode for anemometer m = 0: simple mode, measurement of momentary wind speed m = 1: advanced mode, measurement of average -, maximum- and minimum wind speed	aX_ok<CR><LF>
aXGAM!	Query anemometer mode	a,m<CR><LF>
aXSAMT, t!	Set measurement period Sensor will count the number of pulse during t seconds t = 0.25 to 5 seconds default value is 5 seconds.	aX_ok<CR><LF>
aXGAMT!	Query measurement period	a+t <CR><LF>
aXSRP, t!	Set RTC wakup period RTC will wakup every t seconds and take a measurement t = 3, 4, 5, 6 seconds default value is 6 seconds.	aX_ok<CR><LF>

aXGRP!	Query RTC wakup period	a+t <CR><LF>
aXSAP,t!	Set averaging period t = 3 to 60 seconds Default value is 18 seconds, this value must be a multiple of RTC wakup period seconds	aX_OK <CR><LF>
aXGAP!	Query averaging period	a+t<CR><LF>
aXSLP,t!	Set logging period Default value is 900 seconds (15 minutes) Value 60 seconds to 3600 seconds	aX_OK <CR><LF>
aXSLP!	Query logging period	a+t <CR><LF>
aXSO,+a.aa!	Set offset value Default value is 0,5m/s; this value represents the starting threshold for wind speed measurement	aX_OK <CR><LF>
aXGO!	Query offset value	a+a.aa <CR><LF>

Table 1: *anemometer specific SDI-12 commands*

Extended SDI-12 command to configure the TBS02PA anemometer input: **aXSASF,sn.nnnnnnnn!**

n.nnnnnnnn is the anemometer scaling factor which will be multiplied with the number of pulses sampled over 5 seconds. **It** can be up to 9 digits, with the decimal point anywhere. The result of this multiplication is the value delivered upon a measurement command.

Sample time of the TBS02PA: **5 seconds**

The sample time is chosen relatively long in order to improve the resolution of reed switch based wind vanes at low wind speeds.

The default value of the parameter n.nnnnnnnn is 0.2 which means that the default output is number of pulses/second.

Wind speed can be expressed in various units. The TBS02PA can output any unit. It just needs to be scaled accordingly, using the extended SDI-12 command for anemometer scaling.

1 kn	= 1 sm/h	= 1,852 km/h	= 0,514 m/s
1 m/s	= 3,6 km/h	= 1,944 kn	= 2,237 mph
1 km/h	= 0,540 kn	= 0,278 m/s	= 0,621 mph
1 mph	= 1,609344 km/h	= 0,8690 kn	= 0,447 m/s

Table 2: *wind speed unit conversion*

Example 1:

E.g. from Davis 7911 data sheet: 1600rev/hr ≡ 1mph; 1 pulse per revolution

→1600 rev/hr = 4/9 rev/s; 1rev/s ≡ 9/4mph = 2.25mph

Taking into account the sampling periods of 5 s: V = P(2.25/T)

V = speed in mph

P = no. of pulses per sample period

T = sample period in seconds (5 s)

→ V = P(2.25/5) = 0.45P [mph]
TBS02PA set to address 0
0XSASF,0.45! will deliver the wind speed in mph (miles per hour)

Using the table above:
0XSASF,0.742048! will deliver the wind speed in km/h
0XSASF,0.20115! will deliver the wind speed in m/s
0XSASF,0.39105! will deliver the wind speed in kn (knots)

Example 2:

E.g. from Vector A100LK data sheet:
10 pulses/sec ≡ 1knot;
→ V = P/T*10 [knots]
V = speed in knots
P = no. of pulses per sample period
T = sample period in seconds (5 s)
→ V = P/50) = 0.02P
TBS02PA set to address 0
0XSASF,0.02! will deliver the wind speed in knots

Using the table above:
0XSASF,0.03704! will deliver the wind speed in km/h
0XSASF,0.01028! will deliver the wind speed in m/s
0XSASF,0.02301! will deliver the wind speed in mph

5 Wind vane input

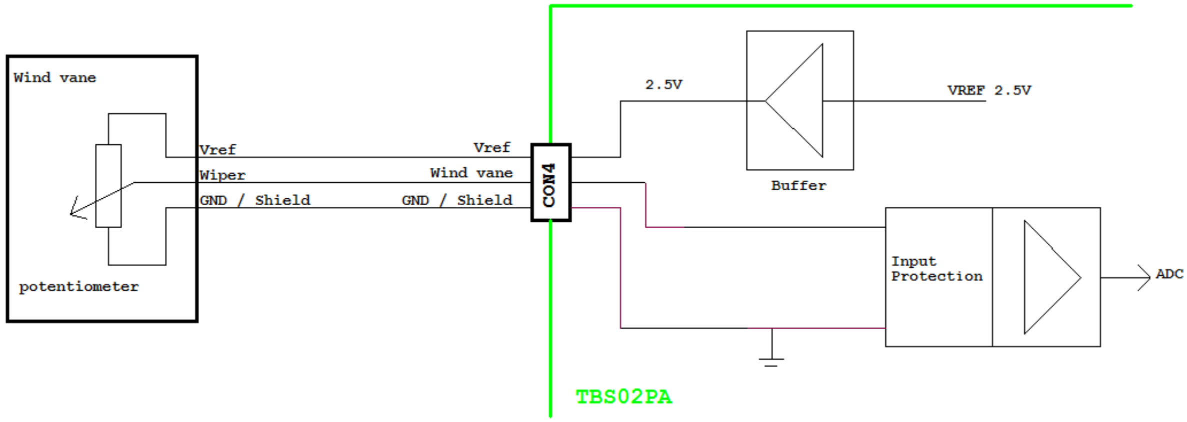

Figure 7 – Connection of a potentiometer based wind vane

aM4!	Start Measurement of the wind vane angle	A0011<CR><LF> delay (001) in seconds and number of values (1)
aMC4!	Additional Measurement and request CRC Measures wind vane angle and calculates CRC	A0011<CR><LF> delay (001) in seconds and number of values (1)
aC4!	Start Concurrent Measurement Concurrent measurement of wind vane angle	A0011<CR><LF> delay (001) in seconds and number of values (1)
aCC4!	Start Concurrent Measurement and request CRC Concurrent measurement of wind vane angle and CRC measurement	A0011<CR><LF> delay (001) in seconds and number of values (1)
aD0!	Get Measurement Result	A+www.w<CR><LF> www.w angle in degrees
aXSSP4,sa,sb,sc,sd!	Set the coefficients of the scaling-polynomial $y = a*x^3 + b*x^2 + c*x + d$ Default coefficients are a = 0; b=0; c=144; d=0	aX_ok<CR><LF>
aXGSP4!	Query the coefficients of the scaling-polynomial	a+a.aaaa+b.bbbb+c.cccc+d.dddd<CR><LF>

Table 3: *wind vane specific SDI-12 commands*

The wind vane input is a 2.5V range analog input which provides a stable 2.5V reference to drive the potentiometer. It is connected to the ADC and can be scaled with a polynomial like the other analog input channels. If no wind vane is connected, the input can be used as an analog input channel for other sensors.

Extended SDI-12 command to configure the TBS02PA wind vane input: **aXSSP4,sa,sb,sc,sd!**

Sa, sb, sc, sd: sign followed by up to 5 digits per coefficient; the decimal point may be at any position; if no sign is added to the coefficient, the number is considered to be positive. In this case, the length of the coefficient can be extended to 6 digits.

$$y = a*x^3 + b*x^2 + c*x + d$$

The wind vane input is by default scaled to 2.5V ≡ 360°; →1V ≡ 144°; → **a = 0 ; b=0; c=144; d=0**
aXSSP4,0,0,144,0!

6 Rain gauge input

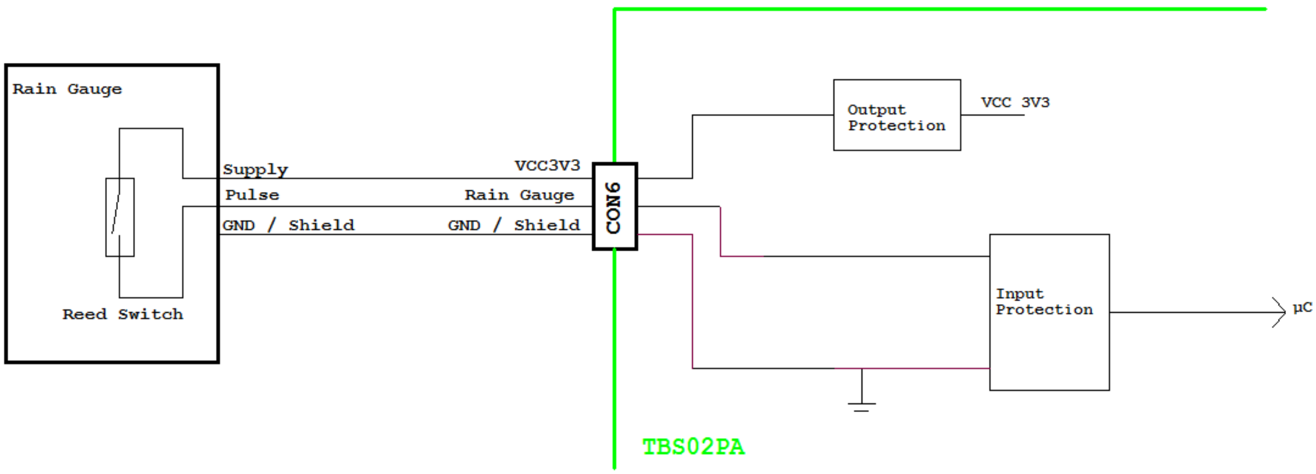

Figure 8 – rain gauge connected to TBS02PA

Connect the rain gauge to the TBS02PA according figure 6.

The TBS02PA will accumulate rainfall independently of the data logger. Consequently **the TBS02PA needs to be continuously supplied with 12 V in case that a rain gauge is connected**. Every pulse of the tipping bucket will create an interrupt and wake up the controller to accumulate the pulse. In between the pulses, the TBS02PA will switch into sleep mode.

As the rain gauge feature of the TBS02PA is delivering accumulated measurements, it is important to set date and time of the RTC. Date and time can be set using a PC and USB to SDI-12 converter, before installing the device in the field. The RTC is buffered by a super capacitor and will hold date and time over several months.

Command	**Description**	**Response**
aXSD,YYYY,MM,DD!	Set date [a] is the sensor address YYYY,MM,DD, is year, month, day	**aX_OK<CR><LF>**
aXST,HH,MM,SS!	Set time [a] is the sensor address HH,MM,SS, is hour, minute, second (24 hr format)	**aX_OK<CR><LF>**
aXGD!	Query date	**a+YYYY+MM+DD<CR><LF>** no trailing zeros in response
aXGT!	Query time	**a+HH+MM+SS<CR><LF>** no trailing zeros in response

Table 4: *RTC specific SDI-12 commands*

The daily accumulation of rainfall will be automatically reset at 00:00. Upon installation/powering the rain gauge, it will accumulate the daily rainfalls until issuing an extended SDI-12 command to reset the total accumulated value to zero. After reset, accumulation will start again. By default, the start value is zero, however the start value can also be set using an extended SDI-12 command. The reset commands sets all accumulated rainfall values to zero. An additional command is available to overwrite / set a different start value for the total accumulated rainfalls.

aM5!	Start Measurement	A0014<CR><LF> Delay (001) in seconds and number of values (5)
aMC5!	Additional Measurement and request CRC Measures and calculates CRC	A0014<CR><LF> Delay (001) in seconds and number of values (5)
aC5!	Start Concurrent Measurement Measures and calculates CRC	A0014<CR><LF> Delay (001) in seconds and number of values (5)
aCC5!	Start Concurrent Measurement and request CRC Measures and calculates CRC	A0014<CR><LF> Delay (001) in seconds and number of values (5)
aD0!	Get Measurement Result AA.AAA accumulated rainfall since last measurement BB.BBB accumulated rainfall of today (starting at 00:00) CC.CCC accumulated rainfall of yesterday DDDD.DDD total accumulated rainfall since reset command the decimal point can be anywhere, no leading zeros	a+AA.AAA+BB.BBB+CC.CCC+DDDD.DDD <CR><LF>
aXSBV, sn.nn!	Set rain gauge bucket volume n.nn is the equivalent rainfall in mm or inch, per bucket tip	aX_ok<CR><LF>
aXGBV!	Query rain gauge bucket volume n.nn is the equivalent rainfall in mm or inch, per bucket tip	A+n.nn<CR><LF>
aXRS!	Reset total accumulated rainfalls Use this command to set all accumulated rainfall values to zero.	aX_ok<CR><LF>
aXGRS!	Query date of last reset	a+YYYY+MM+DD<CR><LF>
aXSO, snnnn.nn!	Set start value/offset for the total accumulated rainfalls	aX_ok<CR><LF>
aXGO!	Query start value/offset for the total accumulated rainfalls	a+nnnn.nn<CR><LF>

Table 5: *rain gauge specific SDI-12 commands*

Power management:

If a rain gauge is connected to the TBS02PA, it requires continuous supply. Total power consumption nevertheless is low, as the supply for the other connectors is only switched on during a measurement. The TBS02PA will be in a very low power mode unless tipping of the rain gauge bucket generates an interrupt and wakes up the controller for a short period of time.

A power cut will not cause the loss of any accumulated rainfall value.

7 Analog inputs

The TBS02PA provides 4 analog inputs with input ranges of:

Channel 0 0…1V

Channel 1 0…2.5V

Channel 2 0…0.25V, 0…0.5V, 0…5V (only either one of the two CH2 inputs can be connected at a time)

Channel 3 0…20mA

All inputs are mapped to the 0…2.5V measurement range of the ADC. This means that the maximum measurement result without scaling will be 2.5V in any range. The measured parameter of the sensor can easily be responded in its correct units, using extended SDI-12 commands for scaling. Another point to be taken care of is the response time of the sensor. This can also be configured with dedicated SDI-12 commands.

aM! **aM1!** **aM2!** **aM3!**	Measurement Channel0 Additional Measurement Channel1 Additional Measurement Channel2 Additional Measurement Channel3	A00n1<CR><LF> Delay (00n) in seconds, number of values (1)
aMC! **aMC1!** **aMC2!** **aMC3!**	Measurement and request CRC Channel0 Additional Measurement and request CRC Channel1 Additional Measurement and request CRC Channel2 Additional Measurement and request CRC Channel3	A00n1<CR><LF> Delay (00n) in seconds, number of values (1)
aC! **aC1!** **aC2!** **aC3!**	Concurrent Measurement Channel0 Concurrent Measurement Channel1 Concurrent Measurement Channel2 Concurrent Measurement Channel3	A00n1<CR><LF> Delay (00n) in seconds, number of values (1)
aCC! **aCC1!** **aCC2!** **aCC3!**	Start Concurrent Measurement and request CRC Channel0, Channel 1, Channel2, Channel3	A00n1<CR><LF> Delay (00n) in seconds, number of values (1)
aD0!	Get Measurement Result	a+n.nnnn <CR><LF>
aXSRTn, ttt!	Set response time n = 0…3 Channel number; ttt = response time in seconds; default value is 3 seconds	aX_ok<CR><LF>
aXSCH2,m!	Set input voltage range for channel 2: m = 2: 0 … 0.25V input voltage range m = 1: 0 … 0.5V input voltage range m = 0: 0 … 5V input voltage range (default)	aX_oK<CR><LF>
aXGCH2!	Query input voltage range for channel 2	a,m<CR><LF>
aXSSPn,sa,sb, sc,sd!	Set the coefficients of the scaling-polynomial n = 0…3 Channel number a, b, c, d: scaling coefficients; s = sign; no sign means positive scaling polynomial: $y = a*x^3 + b*x^2 + c*x + d$ x is the voltage at the ADC input; range 0 to 2.5V the scaling polynomial is applied to every measurement with default values: a=0, b=0, c=1, d=0	aX_ok<CR><LF>
aXGSPn!	Query the coefficients of the scaling-polynomial n = 0…3 Channel number	a+a.aaaa+b.bbbb+c.cccc+d.dddd<CR><LF>

Table 6: *analog input specific SDI-12 commands*

Example 1:

Setra barometric pressure sensor model 278
supply voltage: 9.5 – 28VDC
measurement range: 500 – 1100hPa
output voltage range: 0 – 5V → connect to Channel2

In order to output the measurement results in hPa, the coefficients of the scaling polynomial need to be determined:

The output of the sensor is linear; consequently the coefficients of the nonlinear terms are 0.
a = 0 **b = 0**; the polynomial can be simplified to **$y = 0*x^3 + 0*x^2 + c*x + d = c*x + d$**
An output value of 0V corresponds to a barometric pressure value of 500hPa.
y = c*x + d → **500 = c*0 + d** → **d = 500**
A sensor output value of 5V results in 2.5V at the ADC input and corresponds to a barometric pressure value of 1100hPa.
1100 = 2.5*x + d → **1100 = c*2.5 + 500** → **600 = c*2.5** → **c = 240**
The sensor is connected to Channel 2 → **n=2** and assuming the TBS02PA being set to SDI-12 address **a=0** completes the parameters required for the polynomial scaling command.
aXSSPn,sa,sb,sc,sd! → the required scaling command is **0XSSP2,0,0,+240,+500!**
Note: The datasheet is not specifying any temperature dependence of the sensor characteristics. Consequently no temperature compensation will be applied.

7.1 Temperature compensation

The TBS02PA provides a silicon temperature sensor which can be utilized for temperature compensation of sensor output signals or simply to measure temperature.

Parameter	Min	Typ	Max	Unit
Temperature Resolution		0.1		°C
Initial accuracy @ 25°C		0.5	1	°C
Linearity over temperature		±2	±4	°C
range	-40		+85	°C

Table 7: *Temperature sensor characteristics*

The temperature compensation is based on a third order polynomial. The temperature compensation is applied to any measurement of the analog input channels; however the coefficients are set by default in order to not take any effect on the scaled measurement results. Depending on the temperature characteristics of the sensor, the coefficients can be modified in order to effectively compensate temperature drift and other temperature dependent effects. Calculation is explained further down in this chapter.

aM7!	Start Temperature Measurement	A0011<CR><LF> Delay (001) in seconds, number of values (1)
aMC7!	Additional Temp. Measurement and request CRC	A0011<CR><LF> Delay (001) in seconds, number of values (1)
aC7!	Start Concurrent Temperature Measurement	A0011<CR><LF> Delay (001) in seconds, number of values (1)
aCC7!	Start Concurrent Temperature Measurement and request CRC	A0001<CR><LF> Delay (001) in seconds, number of values (1)
aD0!	Get Measurement Result	a+nnn.n <CR><LF>
aXSTPn,sa,sb, sc,sd!	Set the coefficients of the temperature-compensation polynomial n = 0…3 Channel number a, b, c, d: temperature compensation coefficients; s = sign x is the measurement result of channel n; range 0 to 2.5V y is the temperature compensated measurement result temp. compensation polynomial: $y = x(a*t^3+b*t^2 + c*t + d)$ the temperature compensation polynomial is applied to every measurement with default values: a=0, b=0, c=0, d=1	aX_ok<CR><LF>
aXGTPn!	Query the coefficients of the temperature-compensation polynomial n = 0…3 Channel number	a+a.aaaa+b.bbbb+c.cccc+d.dddd<CR><LF>
aXTO,saa.aa,u!	Set temperature offset u = unit: c,C = Celsius f,F = Fahrenheit	aX_ok<CR><LF>
aXTUu!	Set temperature unit u = F for [°C], u = f for [°F]	aX_ok<CR><LF>
aXGU!	Query temperature unit	a,u <CR><LF>
aXCT,saa.aa!	Temperature calibration saa.aa: enter ambient temperature measured with a reference thermometer; s is the sign	aX_ok<CR><LF>

Table 8: *Temperature measurement/compensation specific SDI-12 commands*

Example 2:

Davis solar radiation sensor 6450

Power supply: 3V ± 10%; 1mA → supply from rain gauge 3.3V supply pin or insert a 9.1V (12V-3V) zener diode (NXP BZX79-C9V1,143 into the supply line. Check the exact voltage of the SDI-12 supply line and change to another Zener Diode, if the available voltage is far off.

Output voltage range: 0 to 2.5V; 1.67mV per W/m^2 → connect to Channel1

Temperature corrections: coeff = 0.12% per °C; ref temp = 25°C

<u>Scaling:</u>

In order to output the measurement results in W/m², the coefficients of the scaling polynomial need to be determined:

The output of the sensor is linear; consequently the coefficients of the nonlinear terms are 0.

a = 0 **b = 0**; the polynomial can be simplified to **$y = 0*x^3 + 0*x^2 + c*x + d = c*x + d$**

A sensor output value of 0V corresponds to a solar radiation value of 0 W/m².

y = c*x + sd → **0 = c*0 + d** → **d = 0**

A sensor output value of 2.5V results in 2.5V at the ADC input and corresponds to a solar radiation value of 2500mV/1.67mV ≡ 1497 W/m².

y = c*x → **1497 = c*2.5**→ **c = 598.8**

The sensor is connected to Channel 1 → **n=1** and assuming the TBS02PA being set to SDI-12 address **a=0** completes the parameters required for the polynomial scaling command.

aXSSPn,sa,sb,sc,sd! → the required scaling command is **0XSSP1,0,0,+598.8,0!**

Temperature compensation:

The data sheet of the sensor specifies: Temperature corrections coeff = 0.12% per °C; ref temp = 25°C

The temperature drift of the sensor signal is linear; consequently the coefficients of the nonlinear terms are 0.

a = 0 **b = 0**; the temp. comp. polynomial can be simplified to **$y = x(0*t^3 + 0*t^2 + c*t + d) = x(c*t + d)$**

Furthermore, the temperature coefficient introduces a positive slope of 0.12% = 0.0012; consequently we have to compensate with a negative slope of the same value → **c = -0.0012**

The reference temperature of the sensor is 25°C, which means that we can simplify the equation for room temperature to y = x or in other form

c*25 + d = 1 → 25c =1 – d → d = 1 - 25c → d = 1 + 25*0.0012

d = 1.03

We need to send following extended SDI-12 command: **0XSTP1,0,0,-0.0012,1.03!**

check:

@ 25°C; y = x(-0.0012*25 + 1.03) = x(-0.03 + 1.03) = x

@ 45°C; the temperature difference to 25°C is 20°C;

Consequently the sensor signal will have a drift of 20*0.12% = 2.4%

Assuming a solar radiation value of 1000W/m², the sensor will measure 1024 W/m² instead;

However, as we apply temperature compensation, the TBS02PA will deliver following value:

y = 1024(-0.0012*45 + 1.03) = 1024*0,976 = 1000W/m²

8 Relay Output

Command	Description	Response
aXSR,1!	Close switching contacts of relay a = sensor address; 0...9, a…z, A…Z	**aX_OK<CR><LF>**
aXSR,0!	Open switching contact of relay a = sensor address; 0...9, a…z, A…Z	**aX_OK<CR><LF>**
aXGR!	Query the status of the relay contacts a = sensor address	**aw <CR><LF>** w: state of relay possible values of w: 0 or 1 0 ≡ contact open;1 ≡ contact closed
aXSTM,HH,MM ,mmmm!	Set timer a = sensor address; 0...9, a…z, A…Z HH,MM; hour, minute; starting time of the event mmmm; duration of the event in minutes (4 digits, maximum value = 1439) At the time set for the timer event, the contacts of the relay will be closed for mmmm minutes.	**aX_OK<CR><LF>**
aXCT!	Clear timer (no timer operation); default state	**aX_OK<CR><LF>**

Table 9: *relay specific SDI-12 commands*

The relay is a latching type relay which toggles upon a short current pulse. Consequently it does not draw any current except for the toggling action.

9 Supported SDI-12 Commands

Following commands are supported by the TBS02PA:

Command	Description	Response
a!	Acknowledge Active	a<CR><LF>
aI!	Send Identification	013TEKBOXVNTBSAB21.0000005xxxxx<CR><LF> With xxxxx representing the serial number
aAb!	Change Address	b<CR><LF> Changing the probe sensor address
?!	Address Query	a<CR><LF>
aM!	Start Measurement Measures voltage at analogue input channel 0	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aM1!	Additional Measurement Measures voltage at analog input channel 1	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aM2!	Additional Measurement Measures voltage at analog input channel 2	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aM3!	Additional Measurement Measures current at analog input channel 3	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aM4!	Start Measurement Measures wind vane angle	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aM5!	Additional Measurement Measures precipitation	attt4<CR><LF> Delay (ttt) in seconds and number of values (1)
aM6!	Additional Measurement Measures wind speed	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aM7!	Additional Measurement Measures temperature	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC!	Start Measurement and request CRC Measures voltage at analog input channel 0 and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC1!	Additional Measurement and request CRC Measures voltage at analog input channel 1 and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC2!	Additional Measurement and request CRC Measures voltage at analog input channel 2 and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC3!	Additional Measurement and request CRC Measures current at analog input channel 3 and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)

aMC4!	Additional Measurement and request CRC Measures wind vane angle and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC5!	Additional Measurement and request CRC Measures precipitation and calculates CRC	attt4<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC6!	Additional Measurement and request CRC Measures wind speed and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC7!	Additional Measurement and request CRC Measures temperature and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aC!	Start Concurrent Measurement Measures voltage at analogue input channel 0	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aC1!	Start Concurrent Measurement Measures voltage at analogue input channel 1	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aC2!	Start Concurrent Measurement Measures voltage at analogue input channel 2	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aC3!	Start Concurrent Measurement Measures current at analogue input channel 3	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aC4!	Start Concurrent Measurement Measures wind vane angle	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aC5!	Start Concurrent Measurement Measures precipitation	attt4<CR><LF> Delay (ttt) in seconds and number of values (4)
aC6!	Start Concurrent Measurement Measures wind speed	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aC7!	Start Concurrent Measurement Measures temperature	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC!	Start Concurrent Measurement and request CRC Measures voltage at input channel 0 and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC1!	Start Concurrent Measurement and request CRC Measures voltage at input channel 1 and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC2!	Start Concurrent Measurement and request CRC Measures voltage at input channel 2 and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC3!	Start Concurrent Measurement and request CRC Measures current at input channels 3 and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)

aCC4!	Start Concurrent Measurement and request CRC Measures wind vane angle and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC5!	Start Concurrent Measurement and request CRC Measures precipitation and calculates CRC	attt4<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC5!	Start Concurrent Measurement and request CRC Measures wind speed and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC7!	Start Concurrent Measurement and request CRC Measures temperature and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (4)
aD0!	Get Measurement Result(s)	Upon issuing the aD0! Command, the TBS02B will send the measurement results. The response format depends on the measurement command issued before.
aV!	Start Verification	a0000<CR><LF> Not supported
aRn! **aRCn!**	Continuous Measurement Continuous Measurement + CRC	a<CR><LF> Not supported

Table 10 – Standard SDI-12 commands

9.1 Supported Extended Commands

Command	**Description**	**Response**
	Anemometer	
aXSASF,sn.nnn nnnnn!	Set the scaling factor The scaling factor is seven digits with the decimal point at any position. The scaling factor is a multiplicator applied to the number of pulses measured during a 5 second sampling period. It is used to convert the measured number of pulses into wind speed. See examples for calculating the scaling factor in chapter 4. The default scaling factor is 1.	aX_ok<CR><LF>
aXSAMm!	Set mode for anemometer m = 0: simple mode, measurement of momentary wind speed m = 1: advanced mode, measurement of average -, maximum- and minimum wind speed	aX_ok<CR><LF>
aXSAMm!	Set mode for anemometer m = 0: simple mode, measurement of momentary wind speed m = 1: advanced mode, measurement of average -, maximum- and minimum wind speed	aX_ok<CR><LF>
aXGAM!	Query anemometer mode	a,m<CR><LF>
aXSAMT, t!	Set measurement period	aX_ok<CR><LF>

	Sensor will count the number of pulse during t seconds t = 0.25 to 5 seconds default value is 5 seconds.	
aXGAMT!	Query measurement period	a+t <CR><LF>
aXSRP, t!	Set RTC wakup period RTC will wakup every t seconds and take a measurement t = 3, 4, 5, 6 seconds default value is 6 seconds.	aX_ok<CR><LF>
aXGRP!	Query RTC wakup period	a+t <CR><LF>
aXSAP,t!	Set averaging period t = 3 to 60 seconds Default value is 18 seconds, this value must be a multiple of RTC wakup period seconds	aX_OK <CR><LF>
aXGAP!	Query averaging period	a+t<CR><LF>
aXSLP,t!	Set logging period Default value is 900 seconds (15 minutes) Value 60 seconds to 3600 seconds	aX_OK <CR><LF>
aXSLP!	Query logging period	a+t <CR><LF>
aXSO,+a.aa!	Set offset value Default value is 0,5m/s; this value represents the starting threshold for wind speed measurement	aX_OK <CR><LF>
aXGO!	Query offset value	a+a.aa <CR><LF>
	Wind Vane	
aXSSP4,sa,sb,sc,sd!	Set the coefficients of the scaling-polynomial $y = a*x^3 + b*x^2 + c*x + d$ Default coefficients are a = 0; b=0; c=144; d=0 which translates the 0…2.5V ADC range into output values of 0…360° angle	aX_ok<CR><LF>
aXGSP4!	Query the coefficients of the scaling-polynomial	a+a.aaaa+b.bbbb+c.cccc+d.dddd<CR><LF>
	RTC	
aXSD,YYYY,MM,DD!	Set date [a] is the sensor address; YYYY,MM,DD, is year, month, day	aX_OK<CR><LF>
aXST,HH,MM,SS!	Set time [a] is the sensor address; HH,MM,SS, is hour, minute, second (24 hr format)	aX_OK<CR><LF>
aXGD!	Query date	a+YYYY+MM+DD<CR><LF> no trailing zeros in response
aXGT!	Query time	a+HH+MM+SS<CR><LF> no trailing zeros in response
	Rain Gauge	

aXSBV, sn.nn!	Set rain gauge bucket volume n.nn is the equivalent rainfall in mm or inch, per bucket tip	aX_ok<CR><LF>
aXGBV!	Query rain gauge bucket volume n.nn is the equivalent rainfall in mm or inch, per bucket tip	a+n.nn<CR><LF>
aXRS!	Reset total accumulated rainfalls Use this command to set the all accumulated rainfall values to zero.	aX_ok<CR><LF>
aXGRS!	Query date of last reset	a+YYYY+MM+DD<CR><LF>
aXSO, snnnn.nn!	Set start value/offset for the total accumulated rainfalls	aX_ok<CR><LF>
aXGO!	Query start value/offset for the total accumulated rainfalls	a+nnnn.nn<CR><LF>
Analog Input Channels		
aXSRTn, ttt!	Set response time n = 0…3 Channel number; ttt = response time in seconds; default value is 3 seconds	aX_ok<CR><LF>
aXSSPn,sa,sb,sc,sd!	Set the coefficients of the scaling-polynomial n = 0…3 Channel number a, b, c, d: scaling coefficients; s = sign; no sign means positive scaling polynomial: $y = a*x^3 + b*x^2 + c*x + d$ x is the voltage at the ADC input; range 0 to 2.5V the scaling polynomial is applied to every measurement with default values: a=0, b=0, c=1, d=0	aX_ok<CR><LF>
aXGSPn!	Query the coefficients of the scaling-polynomial n = 0…3 Channel number	a+a.aaaa+b.bbbb+c.cccc+d.dddd<CR><LF>
aXSTPn,sa,sb,sc,sd!	Set the coefficients of the temperature- compensation polynomial n = 0…3 Channel number a, b, c, d: temperature compensation coefficients; s = sign x is the measurement result of channel n; range 0 to 2.5V y is the temperature compensated measurement result temp. compensation polynomial: $y = x(a*t^3+b*t^2 + c*t + d)$ the temperature compensation polynomial is applied to every measurement with default values: a=0, b=0, c=0, d=1	aX_ok<CR><LF>
aXGTPn!	Query the coefficients of the temperature- compensation polynomial n = 0…3 Channel number	a+a.aaaa+b.bbbb+c.cccc+d.dddd<CR><LF>
aXSCH2,m!	Set range for channel 2: m = 2: 0 … 0.25V input voltage range m = 1: 0 … 0.5V input voltage range m = 0: 0 … 5V input voltage range (default)	aX_OK<CR><LF>
aXGCH2!	Query range for channel 2	a,m<CR><LF>
Relay		
aXSR,1!	Close switching contacts of relay a = sensor address; 0...9, a…z, A…Z	aX_OK<CR><LF>
aXSR,0!	Open switching contact of relay	aX_OK<CR><LF>

	a = sensor address; 0...9, a…z, A…Z	
aXGR!	Query the status of the relay contacts a = sensor address	aw <CR><LF> w: state of relay – 0 or 1 0 ≡ contact open;1 ≡ contact closed
aXSTM,HH,MM, mmmm!	Set timer a = sensor address; 0...9, a…z, A…Z HH,MM; hour, minute; starting time of the event mmmm; duration of the event in minutes (4 digits, maximum value = 1439) At the time set for the timer event, the contacts of the relay will be closed for mmmm minutes	aX_OK<CR><LF>
aXCT!	Clear timer (no timer operation); default state	aX_OK<CR><LF>

Table 11 – Extended SDI-12 Commands

10 Application Example

This chapter is a practical guide on how to set up a TBS02PA, interface it to a PC with a TBS03 SDI-12 to USB converter and carry out measurements.

10.1 Setting up TBS02PA together with TBS03

10.1.1 Requirements

User Interface

Any hyper terminal (e.g.: Windows Hyper Terminal, Terminal V1.9B, RealTerm) or SDI-12 commander light.

Hardware Interface

PC or laptop with USB interface and mini USB-B cable (USB cable supplied with TBS03)

10.1.2 Driver

Silicon Labs CP210x driver must be installed on PC (on CD supplied with TBS03 or download from Silicon Labs)

Do not connect TBS03 to the PC, when starting the CP2102 driver installation process!

1) Start the driver installation executable

2) Follow the installation instructions step by step until the driver installation process is finished

3) The system may need to restart

4) Upon restart after successful driver installation (and not before), connect the TBS03 to the USB interface of the PC

5) Wait until you get the notification that the new hardware has been installed and are ready to use.

Some terminal programs need manual COM port set up.

Open the hardware manager to check the COM port number assigned to the Silicon Labs USB Bridge.

Every TBS03 device is serialized with an individual number. This enables the use of several TBS03's in parallel on a single PC or Laptop.

10.2 Hardware

- Connect the USB / SDI-12 Converter to the PC via USB port.
- Connect the TBS03 SDI-12 data interface to the TBS02PA SDI-12 Interface.
- Connect a voltage source 0 < V < 2,5V to channel 0

10.3 Setting up SDI-12 Commander Lite

- Download SDI-12 Commander Lite from the Tekbox website (TBS03 page) and decompress it to your hard disk.
- No further installation process is required. Execute *SDI12_commander_lite.exe*.

10.4 Operating the TBS02PA using SDI-12 Commander Lite

Start *SDI-12 Commander Lite*.

Click the “Settings”, “COM Port” menu and select the correct COM Port number. Click the “Connect” button in the main window to activate the Com Port.

In the “File” menu, click “add sensor to the network”. Click the TBS02PA picture in the pop-up window and press “OK”

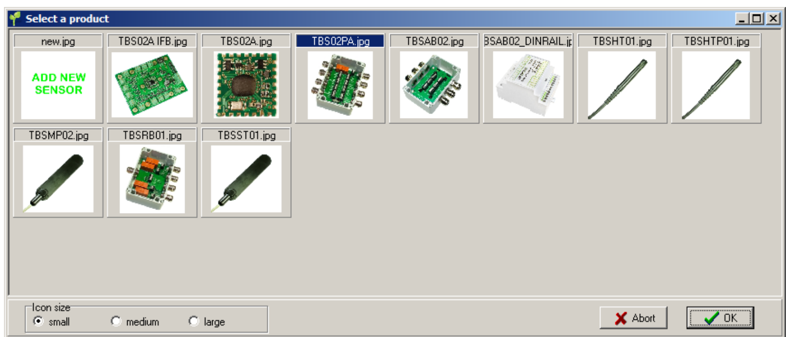

Figure 9 –SDI-12 Commander Lite: sensor selection

A tab containing the SDI-12 commands for the TBS02PA will be added:

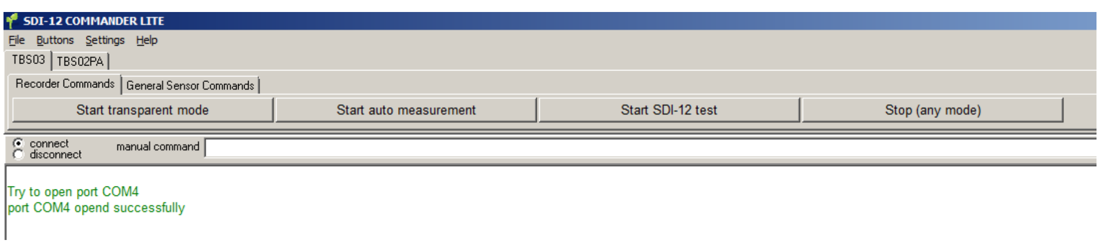

Figure 10 – command tab for TBS02PA added

Clicking the tab for the TBS02PA opens further tabs with command buttons for all features of the TBS02PA.

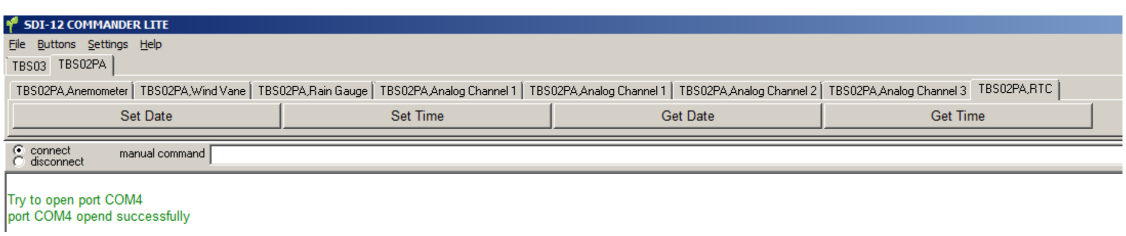

Figure 11 – Anemometer command buttons

10.4.1 Setting time and date

Press the TBS02PA / RTC tab and press the date button.

The TBS03 will issue the string 0XSD,YYYY,MM,DD! and response with 0X_fail as the command string only contained place-holder characters for the date. However you now got the command into the command line and you can easily edit it. Replace YYYY,MM,DD with the actual date and press the red button to the right of the command line.

Repeat the same process with the actual time.

Alternatively you could straight away type the extended SDI-12 command with the actual date / time into the command line and press the red button to the right of the command line.

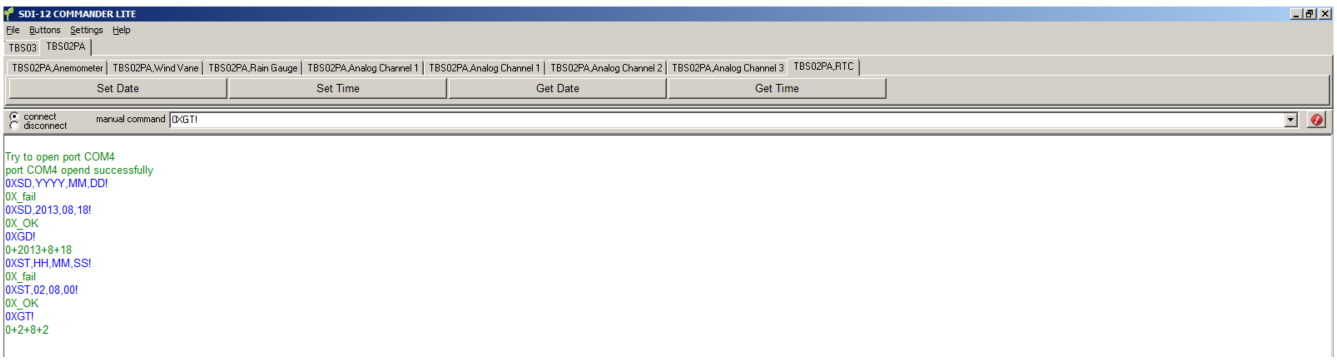

Figure 12 – setting date and time

10.4.2 Setting parameters for wind vane, anemometer and rain gauge

Assumptions:

TBS02PA set to address0

Connection of a Davis 7911 wind vane / anemometer:

Wind speed to be calculated in km/h; required setting according to chapter 4: **0XSASF,0.27945!**

Wind direction in angular degree; required setting according to chapter 5: **0XSSP4,0,0,144,0!**

Connection of a Setra barometric pressure sensor model 278 to analog Channel2:

Scaling settings according to chapter 7: **0XSSP2,0,0,+240,+500!**

Connection of a Davis solar radiation sensor 6450 to analog Channel1:

Scaling settings according to chapter 7: **0XSSP1,0,0,+598.8,0!**

Temperature compensation to chapter 7: **0XSTP1,0,0,-0.0012,1.03!**

Click “Buttons”, “Edit buttons”. A pop-up window will open. Click “New” and enter the name of an additional page for the TBS02PA tab: e.g. “Settings”.

Enter the extended SDI-12 commands accordingly and assign names to the command buttons.

Press the “OK” button to add the settings page to the TBS02PA tab.

If you want to permanently save the settings page to the TBS02PA button file, click the “File” menu, “Save button file”. Click “Save”. A window will pop up and ask to add a user defined picture to the sensor. As there is already a picture assigned to the TBS02PA, click “Abort”.

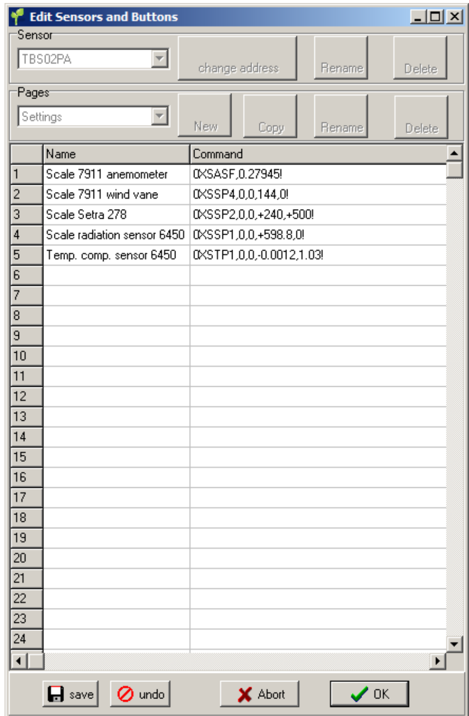

Figure 13 – "Edit buttons" window

Alternatively you could open the file TBS02PA.btn in the template folder of the SDI-12 Commander Lite directory and append the new buttons/commands with a text editor:

………………..

```
 [Settings]
Scale 7911 anemometer=0XSASF,0.27945!
Scale 7911 wind vane=0XSSP4,0,0,144,0!
Scale Setra 278=0XSSP2,0,0,+240,+500!
Scale radiation sensor 6450=0XSSP1,0,0,+598.8,0!
Temp. comp. sensor 6450=0XSTP1,0,0,-0.0012,1.03!
```

Finally, click the settings tab and consecutively press the settings buttons.

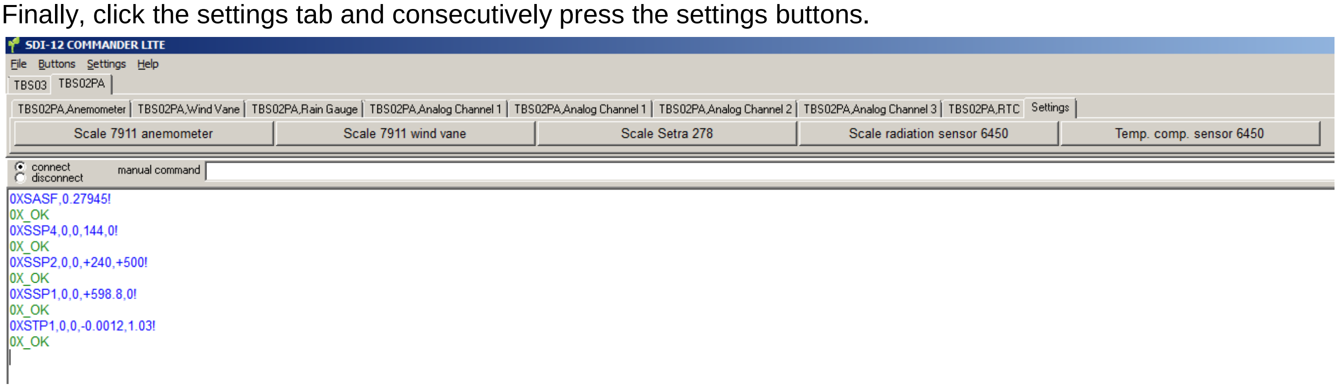

Figure 14 – "Edit buttons" window

The TBS02PA is now configured. All settings are stored in EEPROM. It is ready to be installed in the field.

11 Technical Specifications

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Is	Supply current [1]	Active mode (during measurement)	6mA		10mA	mA
Is	Supply current	Sleep mode		30		µA
Vs	Supply voltage [2]		7		16	V
tm	Measurement Time [3]	Time in active mode upon receiving a measurement command		1		s
Vr	Voltage measurement range	Analog channel0	0		1	V
Vr	Voltage measurement range	Analog channel1	0		2.5	V
Vr	Voltage measurement range	Analog channel2	0		5	V
Vr	Current measurement range	Analog channel3	0		20	mA
R	Voltage measurement resolution			12		Bit
Vref	2.5V reference voltage accuracy			±2 5		mV ppm/°C
TR_int	Internal sensor: Temperature measurement range		-40		+85	°C
TA_int	Internal sensor: Temperature calibration accuracy	@ 25°C		±0.5	±1	°C
TL_int	Internal sensor: Temperature measurement resolution			0.1		°C
TL_int	Internal sensor: Temperature measurement linearity	from -40°C to +85°C		±2	±4	°C
ZIN_v	Input Impedance	voltage measurement mode		1M		MOhm
ZIN_i	Input Impedance	current measurement mode		125		Ohm
OV_V	Input overvoltage protection	Varistor, spark gap, clamping diodes max. continuous overvoltage			30	V

1) The total current consumption depends on the current consumption of the connected sensors
2) Note: The supply voltage range refers to the TBS02PA. The min/max supply voltage of external sensors which are supplied through the sensor supply terminals of the TBS02PA may differ from the supply voltage range of the TBS02PA.
3) Depends on response time setting

Table 12 – Technical Specifications

12 Environmental Specifications

Symbol	Parameter	Conditions	Min	Max	Unit
T_A	Operating Ambient Temperature Range		-40	+85	°C
T_{STG}	Storage Temperature Range		-40	+85	°C
	Moisture level	closed housing	-	100	%

Table 13 - Environmental Specifications

13 Ordering Information

Part Number	Description
TBS02PA	TBS02PA, Analogue to SDI-12 Interface, Fibox housing
TBS02PA-DR	TBS02PA, Analogue to SDI-12 Interface, DIN-Rail housing

Table 14 – Ordering Information

14 History

Version	Date	Author	Changes
V1.0	18.08.2013	Mayerhofer	Creation of the document
V1.1	22.08.2013	Mayerhofer	Correction of the default anemometer scaling factor
V1.2	29.08.2013	Mayerhofer	Formatting
V1.3	09.10.2013	Mayerhofer	Correction of example 1,2/ in chapter 4
V1.4	11.18.2013	Thinh	Added: Set input voltage range for channel 2
V1.5	11.01.2014	Thinh	Advanced measurement mode for anemometer added
V1.6	28.05.2014	Mayerhofer	Correction of table 8

Table 15 – History