V1.0

TBS02B

SDI-12 / ANALOG Interface Module

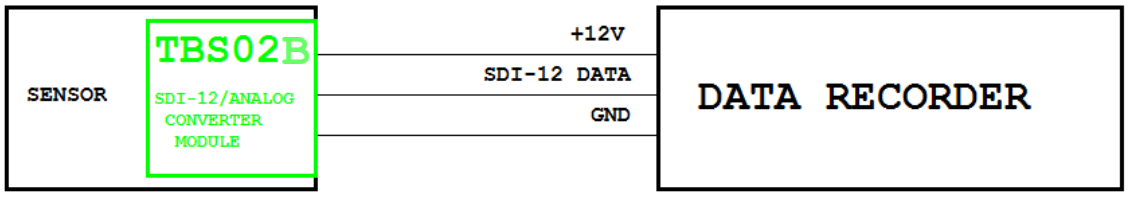
The TBS02B SDI-12 / ANALOG module is a SDI-12 interface for A/D conversion of sensor signals. A/D conversion and configuration of TBS02B is controlled by SDI-12 commands. This is a Plug and Play module which targets cost sensitive sensor applications. It offers low current consumption, small footprint and easy integration into sensor products which require a SDI-12 interface.

The user does not need to invest any time for the implementation of the SDI-12 protocoll and interface hardware, as this is an integral part of the SDI-12 / ANALOG interface module.

The TB02B contains all the necessary components for a complete SDI-12 sensor interface. It includes SDI-12 front-end, controller, crystal and passive components. The TBS02B is a fully compatible replacement of the TBS02A.

The TBS02B has been engineered specifically for applications where cost, performance, time to market and ease of integration are prime considerations.

TBS02B module application



Features

- SDI-12 / ANALOG Interface
- 8 x 12 Bit ADC channels
- 1 x 12 Bit DAC output
- Integrated 12 Bit temperature sensor
- 8 x digital output - configurable sensor power management signal for each channel
- Configurable slope and offset for each channel
- Configurable format for each channel
- Integrated temperature sensor with +/- 0.5 degree accuracy
- Reference voltage input
- Power Down Mode
- SDI-12 Standard V1.3
- Plug and Play
- 3.3V, 5V supply voltage
- 19 mm x 18 mm SMT footprint
- 2.3mm module thickness
- Operating Temperature Range: - 40°C - + 85°C

Target Applications

- SDI-12 Sensors

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50/11 Truong Son, F2 | Q. Tan Binh | Ho Chi Minh City | Tel +84 (83)5471340 | E-mail office@tekbox.net| www.tekbox.net

Contents

Tables

Figures

1 Introduction

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 through one cable. It supports up to 60 meters of 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 and dates from July 18th, 2005. The standard is available on the website of the SDI-12 Support Group.

The TBS02B module implements all the needed functions for interfacing an analog sensor with a SDI-12 data line.

The maximum ADC reference voltage is 3.3V. Power management of external Operational Amplifiers for signal conditioning / sensor hardware can be controlled by individual control signals for each. A 12-Bit DAC is available for additional control requirements. Power management and DAC can be controlled through Extended SDI-12 commands. The TBS02B module contains an internal 12 Bit digital Temperature sensor.

1.1 Product Features

TBS02B is based on a low power controller and a robust SDI-12 interface hardware:

- 5V, 1200 baud SDI-12 data interface with transient protection
- 8 x 12 Bit ADC channels
- 12 Bit digital temperature sensor
- 8 x digital control signals
- 1 x 12 Bit DAC channel
- Integrated temperature sensor with +/- 0.5 degre accuracy
- Power Down Mode
- 3,3V, 5V supply voltage
- Operating temperature range: -40 - +85°C

Firmware feature overview:

Measurement commands to measure the voltages at the eight ADC input channels (M, C, R)

Measurement commands to measure temperature

Extended SDI-12 command to set sensor ID

Extended SDI-12 command to define the response time of each channel

Extended SDI-12 command to define the turn off delay time of each power management signal (define delay time for deactivation; the digital signal will go active after receiving a measurement command and become deactivated after a time defined by the extended command)

Extended SDI-12 command to scale and offset the digital output values

Extended SDI-12 command to define an offset for the temperature measurement result

2 Block Level Diagram

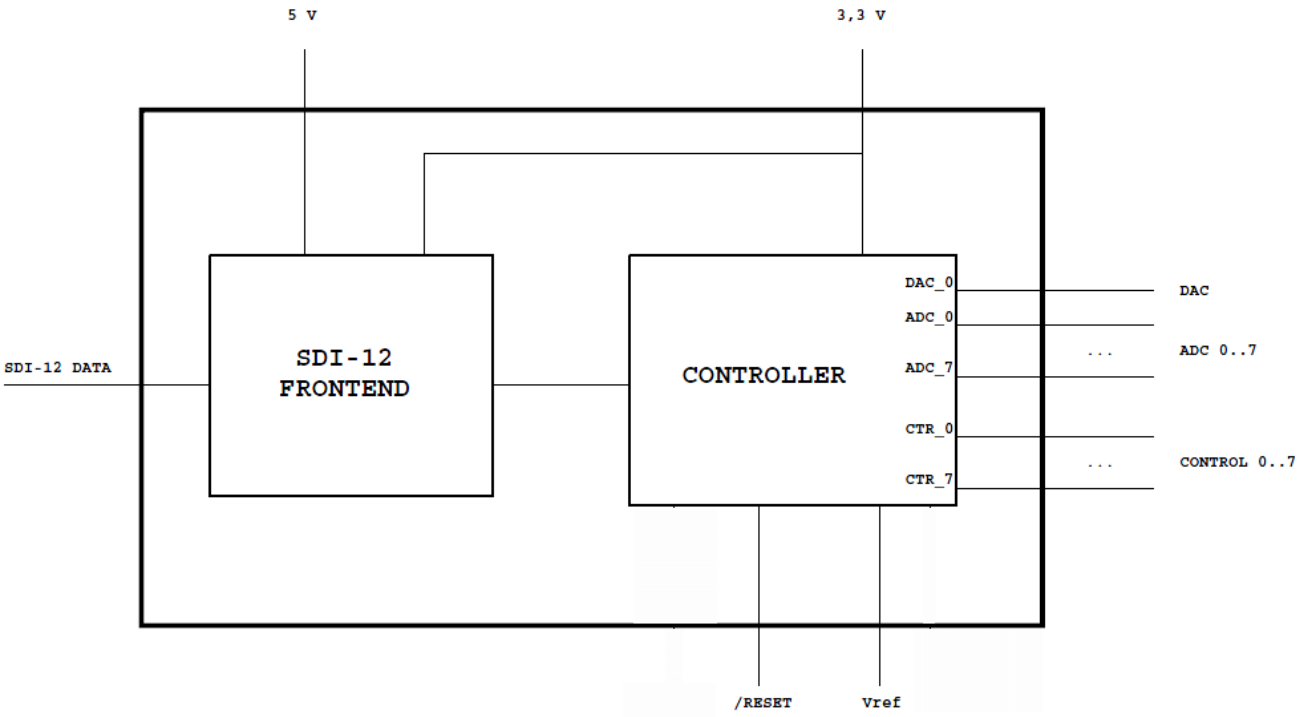


Figure 1 –TBS02B Block Diagram

3 Functional Description

3.1 Interface function

The SDI-12 standard defines a set of commands to configure sensors and to initiate measurements. Upon receiving specific commands, the sensor may carry out internal tasks, respond with information on conversion time or send measurement data.

SDI-12 commands are typically ASCII strings generated by the data recorder/controller firmware. The TBS02B is connected to the SDI-12 interface of the data recorder controller and interpretes the command strings. Furthermore, the TBS02B module handles breaks, marks and all other details of the SDI-12 protocol.

Upon receiving measurement commands or extended commands originated by a data recorder, TBS02B measures the corresponding ADC channels, temperature and provides the control signals for power management of the analog sensor.

3.2 Power Supplies

The TBS02B operates from a single 3.3V VCC supply and a 5V SDI-12 data interface supply. As the SDI-12 interface provides a 12V line to supply sensors, both module supply voltages should be derived from the 12V SDI-12 supply line. External decoupling capacitors and ferrite beads are recommended. (Refer to application schematic example, Figure 6.)

4 Pin Assignment and Description

4.1 Pin List

This table shows the pin names, their type (AI-analog input, AO-analog output, DI-digital input, DO-digital output, OD-open drain, P-power), whenever they have pull-up/pull-down when in input mode (PU-pull-up, PD-pull-down), the I/O voltage, and the description.

#	Pin Name	Type	PU/PD	Domain	Description
1	ADC_3	AI		3V3	Analog input channel [3]
2	ADC_2	AI		3V3	Analog input channel [2]
3	ADC_1	AI		3V3	Analog input channel [1]
4	ADC_0	AI		3V3	Analog input channel [0]
5	/RESET	DI	PU	3V3	Module Reset
6	GND_1				Ground
7	VCC_3V3	P		3V3	Main power supply
8	GND_2				Ground
9	V_REF	AI		3V or 3.3V	ADC/DAC reference voltage input
10	SDI-12_DATA	DI		5V	SDI-12 Serial Data Interface
11	CTRL_0	DO		3V3	Digital control output [0]
12	CTRL_1	DO		3V3	Digital control output [1]
13	CTRL_2	DO		3V3	Digital control output [2]
14	CTRL_3	DO		3V3	Digital control output [3]

#	Pin Name	Type	PU/PD	Domain	Description
15	CTRL_4	DO		3V3	Digital control output [4]
16	CTRL_5	DO		3V3	Digital control output [5]
17	CTRL_6	DO		3V3	Digital control output [6]
18	CTRL_7	DO		3V3	Digital control output [7]
19	GND_3				Ground
20	VCC_5V	P		5V	SDI -12 data interface power supply
21	GND_4				Ground
22	DAC_0	AO		3V or 3V3	Analog output channel [1]
23	RESERVED	DI	PU	3V3	Do not connect
24	GND5				Ground
25	ADC_7	AI		3V3	Analog input channel [0]
26	ADC_6	AI		3V3	Analog input channel [0]
27	ADC_5	AI		3V3	Analog input channel [0]
28	ADC_4	AI		3V3	Analog input channel [0]

Table 1 – Pin list

4.2 Module Pin Descriptions

4.2.1 V_REF

ADC reference voltage input.

Recommended reference voltage: 3V or 3.3V

4.2.2 ADC_[0:7]

12-Bit ADC inputs.

4.2.3 DAC_0

12-Bit DAC output.

4.2.4 Digital Control Outputs – CTRL_[0…7]

Digital outputs for power management purpose. The outputs go active upon receiving a measurement command addressing a corresponding ADC channel.

ADC_0 corresponds with CTRL_0 …. ADC_7 with CTRL_7

The outputs go active immediately after receiving a measurement command and go inactive upon delivery of the measurement command. Extended SDI-12 commands can be used to keep it active for a delay of up to 999 seconds after delivering the measurement result.

4.2.5 External Reset – /RESET

The /Reset pin can be left unconnected. The module has an internal Power On Reset, Power Down Reset and Brown Out Detection.

4.2.6 SDI-12_Data

Bi-directional SDI-12 data interface according SDI-12 standard.

4.2.7 RESERVED

Do not connect this pin.

4.2.8 SDI-12 Data Interface Supply Voltage – VCC_5V

Positive 5V supply voltage for the SDI-12 data interface.

4.2.9 Main Module Supply Voltage – VCC_3V3

Positive 3,3V supply voltage.

5 Electrical Characteristics

5.1 Absolute maximum ratings

Stress above the limits listed in the following table may cause permanent failure. Exposure to absolute ratings for extended time periods may affect device reliability. The limiting values are in accordance with the Absolute Maximum Rating System (IEC 134). All voltages are referenced to ground.

Symbol	Parameter	Conditions	Min	Max	Unit
	VCC_3V3	-	- 0.3	4	V
	VCC_5V		-0.3	5.5	V
	Other terminal voltages	-	- 0.3	4	V
V_{ES}	Electrostatic handling(1) & (2)		-	2000	V

(1) Tested according to MIL883C Method 3015.6 (Standardized Human Body Model: 100 pF, 1500Ω, 3 pulses, protection related to substrate).
(2) Static and dynamic latch-up values are valid at room temperature.

Table 2 - Absolute maximum ratings

5.2 Electrical Specifications

Temperature TA = 20°C, VCC_3V3 = 3.3V, VCC_5V = 5V, unless otherwise stated

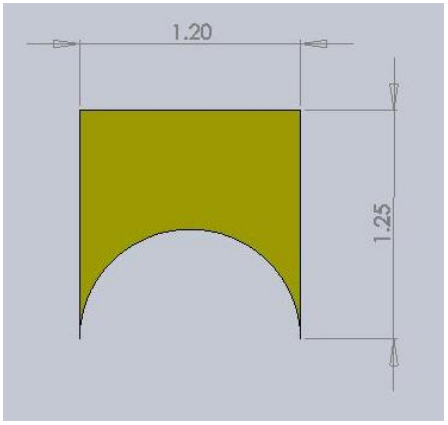
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supply Voltages						
VCC_3V3	Supply Voltage to pin VCC_3V3		3.1	3.3	3.63	V
VCC_5V	Supply Voltage to pin VCC_5V		4.5	5	5.5	V
Supply Currents in run mode						
I_3V3	Supply current to pin VCC_3V3			5.5	7	mA
I_5V	Supply current to pin VCC_5V			40	45	µA
Supply Currents in idle mode						
I_3V3	Supply current to pin VCC_3V3			1	1.5	µA
I_5V	Supply current to pin VCC_5V			40	45	µA
Digital Inputs/Outputs						
Vil	Input low voltage level	LVTTL	-0.3V	0	0.9	V
Vih	Input high voltage level	LVTTL	2.3	3.3	5	V
Vol	Output low voltage level	|Iol| = 2 mA			0.45	V
Voh	Output high voltage level	|Ioh| = 2 mA	2.8			V
/RESET PU	pull-up resistance on /RESET input	Vi = 0V	30	45	60	kΩ
PU	pull-up resistance on other inputs of the 3V3 domain	Vi = 3V	95	100	105	kΩ

Table 3 - Electrical Specifications

6 Mechanical Specifications, Pin assignment

5.1 Package outline and recommend layout

5.1.1 Pad Dimensions



(Viewed from top)

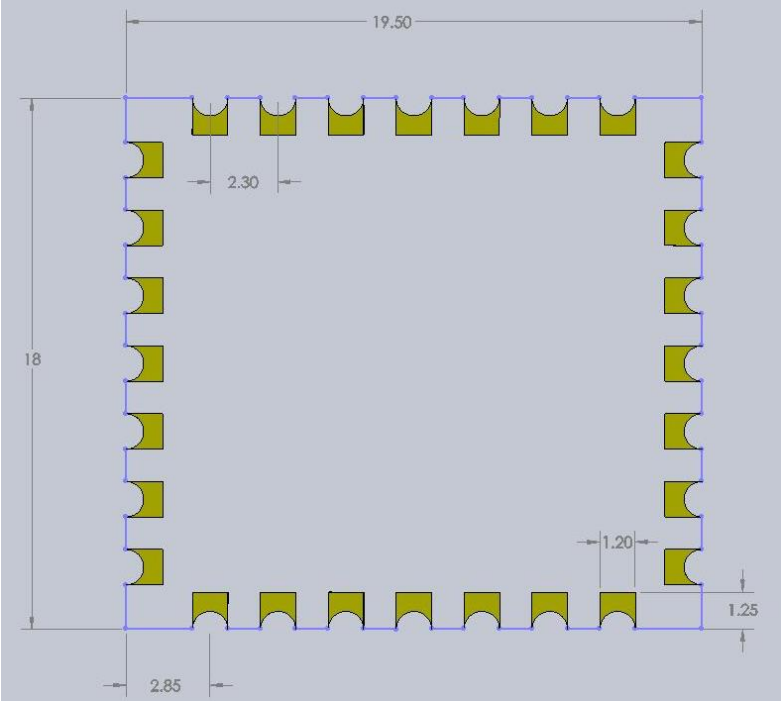
Figure 2 - Pad Dimensions

Pad Dimension Table

PAD Identification	Qty	Pad Dimension
Edge plated pads	28	1.2 x 1.25mm

5.1.2 Package Dimensions

Dimensions are in mm



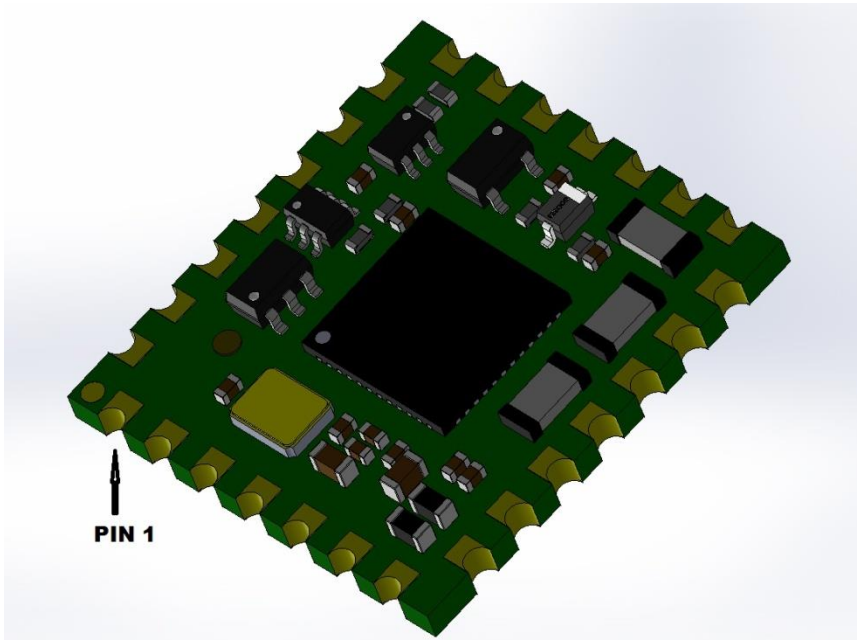
Pin centre Location Table

PIN_NO.	PIN_X	PIN_Y
1	-9.75	6.90
2	-9.75	4.59
3	-9.75	2.30
4	-9.75	0.00
5	-9.75	-2.30
6	-9.75	-4.59
7	-9.75	-6.90
8	-6.90	-9.00
9	-4.59	-9.00
10	-2.30	-9.00
11	0.00	-9.00
12	2.30	-9.00
13	4.59	-9.00
14	6.90	-9.00
15	9.75	-6.90
16	9.75	-4.59
17	9.75	-2.30
18	9.75	0.00
19	9.75	2.30
20	9.75	4.59
21	9.75	6.90
22	6.90	9.00
23	4.59	9.00
24	2.30	9.00
25	0.00	9.00
26	-2.30	9.00
27	-4.59	9.00
28	-6.90	9.00

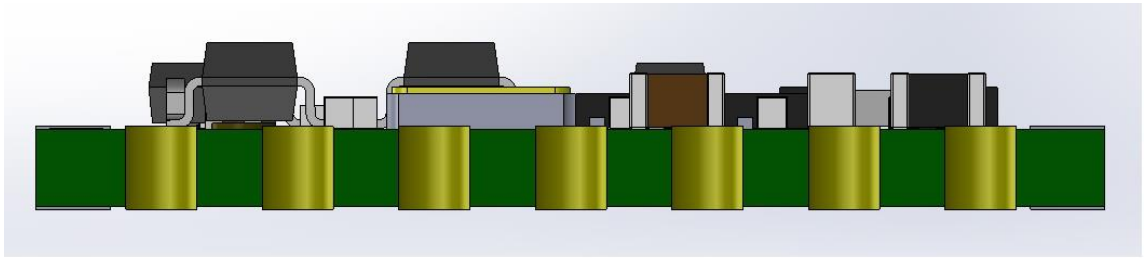
(Viewed from top)

Figure 3 - Package Dimensions

Recommended PCB Pad dimension: 1. 2 x 2mm



(Perspective View)



(Side View; Thickness: 2.3 mm)

Figure 4 - Package details

Module height: 2.3mm ± 0.1mm

5.2 Marking description

With respect to the position of Pin 1, refer to perspective view, figure 4 above

6 Supported commands

6.1 Acknowledge Active Command

The Acknowledge Active Command can be used to ensure that the TBS02B module is responding to a SDI-12 master device.

COMMAND	RESPONSE
a!	a<CR><LF>
a – the sensor address	a – the sensor address
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0!	0<CR><LF>

6.2 Send Identification Command

The Send Identification Command queries the TBS02B module for its SDI-12 compatibility level, model number and firmware version number.

COMMAND	RESPONSE
aI!	a13cccccccmmmmmmvvvxxx...xx<CR><LF>
a – the sensor address	a – the sensor address
I –the Send Identification Command	13 – indicates SDI-12 version V1.3 cccccccc – 8 characters vendor identification mmmmmm – 6 characters sensor model identification vvv – 3 characters sensor version number xxx...xxx – 13 characters optional information, used for serial number
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0I!	013TEKBOXVNTBS02B0010000000000001<CR><LF>

By default, the TBS02B has got an identification defined by Tekbox. As the module will be used to equip analog sensors with a SDI-12 interface, there is an extended command to set a new, customized ID. The user should use this command in his manufacturing / configuration process to set the sensor ID according to his own requirements. The Set ID Command is described in chapter 6.8.

6.3 Address Query Command

The Address Query Command is used to determine the address of the module.

COMMAND	RESPONSE
?!	a<CR><LF>
? – the Address Query Command	a – the actual sensor address
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
?!	0<CR><LF>

6.4 Change Address Command

The TBS02B module is delivered with default address 0 (zero).
The Change Address Command is required when the module is set up within a network of SDI-12 sensors. In order to avoid address conflicts, each sensor requires its individual address.

COMMAND	RESPONSE
aAb!	b<CR><LF>
a – the initial sensor address A – the Change Addres Command b – the address to change to	b – the new address of the sensor
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0A1!	1<CR><LF>

6.5 Start Measurement Command

The Start Measurement Command tells the TBS02B module to measure the voltage at the input ADC[0]. Upon receiving this command, the TBS02B module does not respond the measurement value to the data recorder. The module will respond that one measurement value will be available after ttt seconds. The response time ttt has to be defined by the user according to the timing requirements of his analog sensor. The user should use the *"Set Response Time Command"* in their manufacturing / configuration process to set the sensor response time according to his own requirements. The Set Response Time Command is described in chapter 6.9.
After the response time has passed, the data recorder must issue the Send Data Command (D0!) to get the measurement result.

COMMAND	RESPONSE
aM!	atttn<CR><LF>
a – the sensor address	a – the sensor address
M – the Start Measurement Command	ttt – the specified time, in seconds, until the sensor will have the measurement result available n – the number of measurement values the sensor will make and return in one or more subsequent D commands; n is 1 as the TBS02B only measures ADC[0] upon issuing the aM! command
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0M!	00021<CR><LF> (one value will be available after 2 seconds)
Wait 2 seconds	
D0!	0+2.564<CR><LF> (measured value at ADC[0], e.g. 2.546V)

6.6 Additional Measurement Commands

Additional Measurement Commands are required to measure the voltages at the inputs ADC1...ADC7. Upon receiving any of this commands, the TBS02B module does not respond the measurement value(s) to the data recorder. The module will respond that one or more measurement values will be available after ttt seconds. The response time ttt has to be defined by the user according to the timing requirements of each analog output of their sensor. The user should use the *"Set Response Time Command"* in their manufacturing / configuration process to set the sensor response time according to their own requirements. *"The Set Response Time Command"* is described in chapter 6.9.

After the response time has passed, the data recorder must issue the *"Send Data Command"* (D0!) to get the measurement result(s).

COMMAND	RESPONSE
aM1! ... aM9	atttn<CR><LF>
a – the sensor address	a – the sensor address
M – the Start Measurement Command 1 ... 7 – will issue a measurement at ADC input [1 ... 7] 8 – will issue a sequential measurement of ADC[0...3] 9 – will issue a temperature measurement	ttt – the specified time, in seconds, until the sensor will have the measurement result available n – the number of measurement values the sensor will make and return in one or more subsequent D commands; n is 1 as the TBS02B only measures ADC0 upon issuing the aM! command
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE 1	
0M2!	00011<CR><LF> (one value will be available after 1 second)
Wait 1 second	
D0!	0+1.825<CR><LF> (measured value at ADC[2], e.g. 1.825V)
EXAMPLE 2	
0M8!	00054<CR><LF> (four values will be available after 5 seconds)
Wait 5 seconds	
D0! Comment: as the TBS02B module supports scaling of the measured values, the length of the measurement result may exceed the limit specified for additional measurement commands, which is 35 characters. In this case, the module would return only as many measurement values, as can be fitted within a 35 character string. In case that less than 4 measurement values are responded upon a D0! command, issuing a D1! command will deliver the remaining values.	0+0.378+0.023+2.675+1.825<CR><LF> (measured values at ADC[0...3]
EXAMPLE 3	
0M9!	00011<CR><LF> (one value will be available after 1 second)
Wait 1 second	
D0!	23.75 (measured temperature, e.g. 23.75°C)

6.7 Concurrent Measurement Command

The *"Concurent Measurement Command"* tells the TBS02B module to sequentially measure the voltages at all ADC inputs, ADC[0...7]. Upon receiving this command, the TBS02B module does not respond the measurement values to the data recorder. The module will respond that one measurement value will be available after ttt seconds. The response time ttt has to be defined by the user according to the timing requirements of their analog sensor. The user should use the *"Set Response Time Command"* in their manufacturing / configuration process to set the sensor response time according to their own requirements. The Set Response Time Command is described below.

After the response time has passed, the data recorder must issue the *"Send Data Command"* (D0!) to get the measurement results.

Upon issuing a *"Concurrent Measurement Command"*, the sensor will not abort measurement, if other sensors on the bus are also taking measurements at the same time.

COMMAND	RESPONSE
aC!	atttn<CR><LF>
a – the sensor address	a – the sensor address
C – the Start Concurrent Measurement Command	ttt – the specified time, in seconds, until the sensor will have the measurement result available n – the number of measurement values the sensor will make and return in one or more subsequent D commands; n is 8 as the TBS02B sequentially measures ADC[0...7] upon issuing the aC! command
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0C!	00028<CR><LF> (8 values will be available after 2 seconds)
Wait 5 seconds	
D0! Comment: as the TBS02B module supports scaling of the measured values, the length of the measurement result may exceed the limit specified for concurrent measurement commands, which is 75 characters. In this case, the module would return only as many measurement values, as can be fitted within a 75 character string. In case that less than 8 measurement values are responded upon a D0! command, issuing a D1! command will deliver the remaining values.	0+0.378+0.023+2.675+1.825+2.112+0.039+1.115 +0.982<CR><LF> (measured values at ADC[0...7]

6.8 Set ID Command

The *"Set ID Command"* stores a user defined ID of the sensor in the EEPROM of the TBS02B module.
The default ID is 13TEKBOXVNTBS02Bvvvxxxxxxxxxxxxxx with vvv is revision, xxxxxxxxxxxxx being the serial number of the module.

COMMAND	RESPONSE
aXI!	aX_OK <CR><LF>
a – the sensor address	a – the sensor address

XI – the Set ID Command	
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0XITEKBOXVNTBS02B0010000000000001!	
(30 chars)	

6.9 Set Response Time Command

The *"Set Response Time Command"* is required for factory configuration of analog sensors combined with TBS02 modules. It defines the response time required to deliver a measurement value upon receiving a measurement command. After setting the response times according to the requirements of the analog sensor, it will be stored in EEPROM. Response times can be independently configured for each individual ADC channel and dependent on the measurement command.

The default response times are set to one second for the Measurement/Additional Measurement Commands and 8 seconds for the concurrent measurement command.

COMMAND	RESPONSE
aXRTmn,xxx!	aX_OK <CR><LF>
a – the sensor address	a – the sensor address
XRT – the Set Response Time Command m – the measurement command (M for Measurement/Additional Measurement command; C for Concurrent Measurement command) n – 0...7; addresses the ADC channel(aM -> aM7) n – 8; for aM8, measurement of ADC[0...3] n is not used when setting the response time for the Concurrent Measurement Command	
xxx – 0...999; the response time in seconds	
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0XRTC,012! Sets the response time for the Concurrent Measurement Command to 12 seconds	
0XRTM2,001! Sets the response time of ADC[2] for the Additional Measurement Command to 1 second	

6.10 Set Control Output Command

Upon receiving a measurement command for a specific ADC channel, the corresponding digital control output goes "High". This functionality can be used for power management of the analog sensor circuit. If required, the output can be kept high for a certain delay time.
The default delay time is 0 seconds which means that the control output goes "Low" immediately after delivering the measurement result to the data logger.

COMMAND	RESPONSE
aXDTn,xxx!	aX_OK <CR><LF>
a – the sensor address	a – the sensor address
n – 0...7; the digital output channel	
xxx – 0...999; the delay time until deactivation of the control output in seconds	
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0XRDT3,002! Sets a delay time of 2 seconds for digital output channel CTRL_3	

6.11 Scaling Command

The measurement result can be scaled using a third order polynomial function.
Measurement value = y
ADC value = x
Polynomial: y = a*x^3 + b*x^2 + c*x + d
The coefficients a, b, c, d can be set with the *"Scaling Command"*. The sign needs to be defined as well.
In case of linear scaling, the coefficients a and b are 0.
The default values are: a, b, d = 0; c = 1

COMMAND	RESPONSE
aXSCn,saa.aa,sbb.bb,scc.cc,sdd.dd!	aX_OK <CR><LF>
a – the sensor address	a – the sensor address
n – 0...7; the ADC channel	
saa – -999.99 ... +999.99; sign and coefficient a sbb – -999.99 ... +999.99; sign and coefficient b scc – -999.99 ... +999.99; sign and coefficient c sdd – -999.99 ... +999.99; sign and coefficient d	
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0XSC5,+000.02,-003.00,+002.00,+013.45! Scales the voltage at ADC channel [5] by applying the polynomial function 0.02x^3 - 3x^2 + 2x +13.45	
0XSC5,+000.00,+000.00,+001.00,+000.00! Measurement result = Voltage at ADC input	

6.12 Set DAC Value

The Set DAC Value Command sets the output voltage of the DAC output. The set DAC output voltage will be present whenever the module is in active mode.

The default DAC output voltage is 0 Volt. The DAC output voltage will be stored in the EEPROM until it is overwritten by a different value.

COMMAND	RESPONSE
aXD,xxxx!	aX_OK <CR><LF>
a – the sensor address	a – the sensor address
XD – the Set DAC Value Command xxxx – 0...4096; the DAC output voltage; 12 bit; 0V ... Vref	
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0XD,2048! Sets the output voltage of the DAC to Vref/2	

6.13 Set Temperature Offset and Scale

The *"Set Temperature Offset and Scale Command"* is used to calibrate the on chip sensor of the TBS02B module and the Scale option is either Fahrenheit or Celsius. The offset calibration adds a positive or negative offset to the temperature measurement result. The "on chip" temperature sensor has an accuracy of +/- 0.5 degrees.

T = T(on chip) + a
The default values are: a = 0, S = C

COMMAND	RESPONSE
aXTO,saa.aa,S!	aX_OK <CR><LF>
a – the sensor address	a – the sensor address
saa – -99.99 ... +99.99; S is scale. C for Celsius, F for Fahrenheit	
! – terminates the command	<CR><LF> - terminates the response
EXAMPLE	
0XTO,+00.00,C!	

6.14 Set Voltage Reference

TBS02 can option Vref. Set voltage reference the same hardware connected.

The default values : 2.5V

COMMAND	RESPONSE
aXVR,v.v!	aX_OK<CR><LF>
a – the sensor address	a – the sensor address
v.v (volt)	
! – terminates the command	<CR><LF> - terminates the response

EXAMPLE	
aXVR,3.3!	

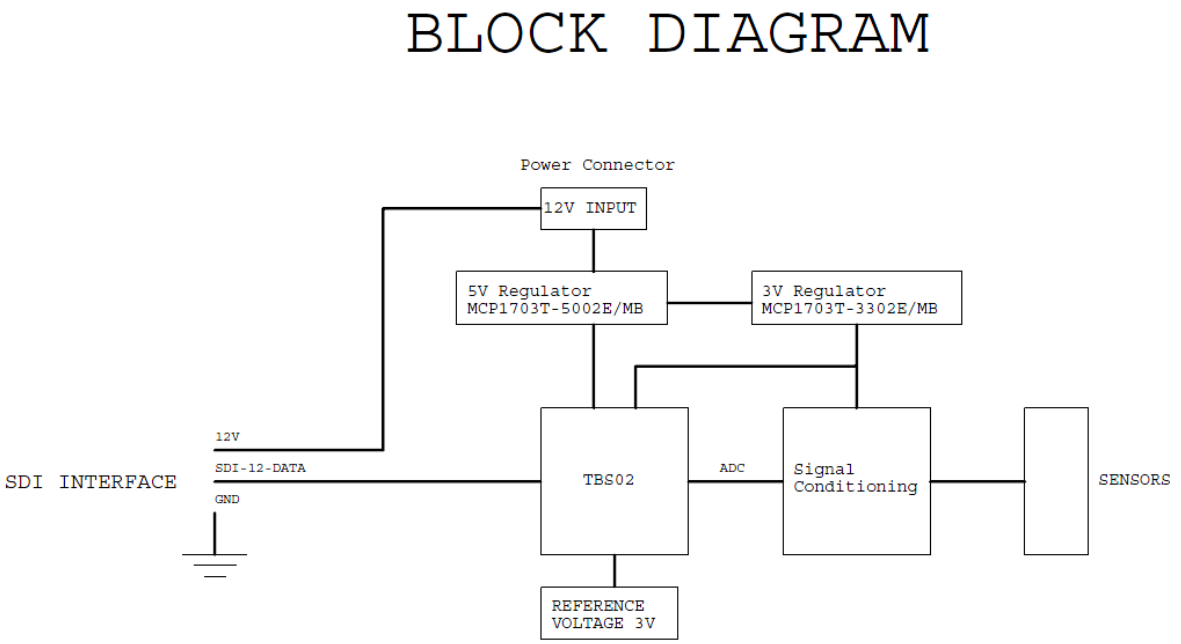
6.15 Get default value

TBS02 support command to load all default value.

COMMAND	RESPONSE
aXGD!	aX_OK<CR><LF>
a – the sensor address	a – the sensor address

1. The sensor address : 0
2. Temperature offset : +00.00 **℃**
3. ADC Scale: a = 0, b = 0, c= 1; d = 0
4. Voltage Reference : 2.5(V)
5. Response Time
    a. ADC channel (aM -> aM7) is **001**(second)
    b. aM8, measurement of ADC[0...3] is **004**(second)
    c. aC, measurement of ADC[0...7] is **008**(second)
    d. aM9, measurement Temperature is **001**(second)
6. Time for turn off ADC : all is 0(second)

7 Application Circuit, TBS02B Evaluation Board



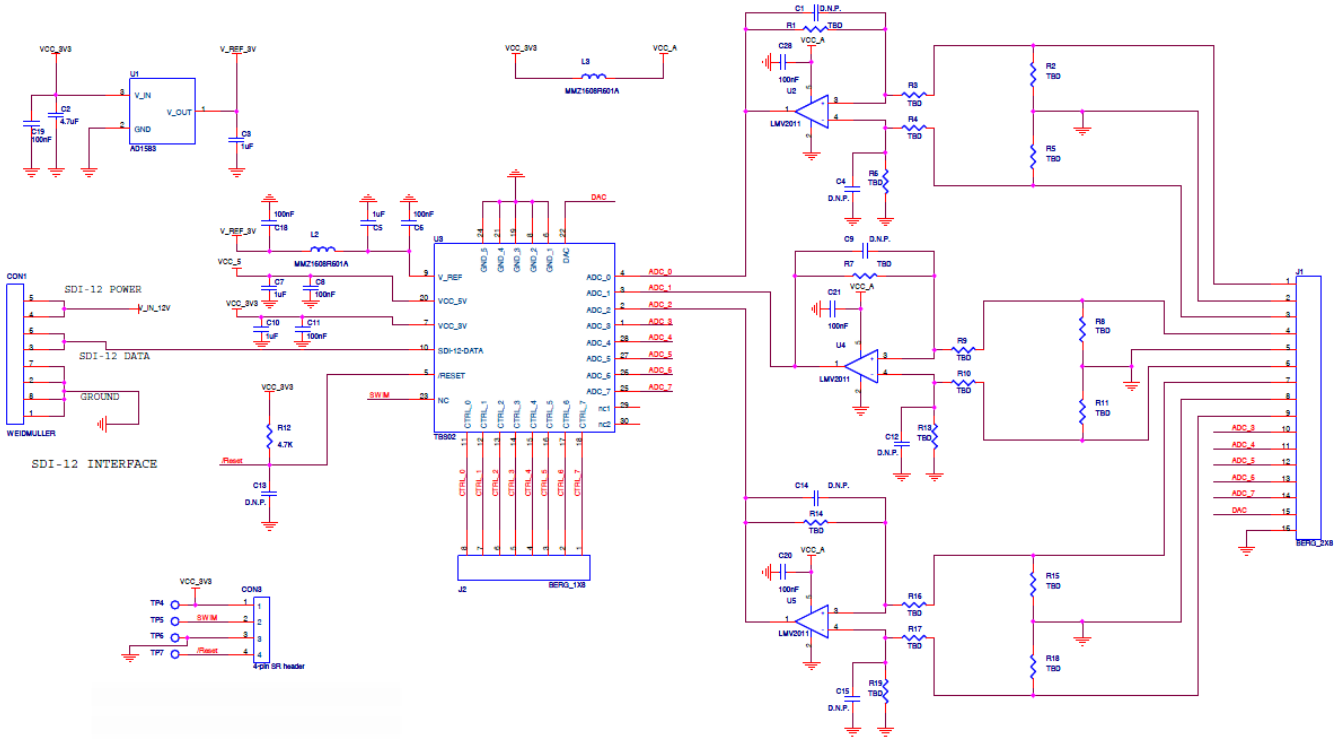


Figure 5 – Standard Application Example

8 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
	Humidity level	Ta=60°C No condensation	-	95	% R.H

Table 4 - Environmental Specifications

9 Soldering Profile

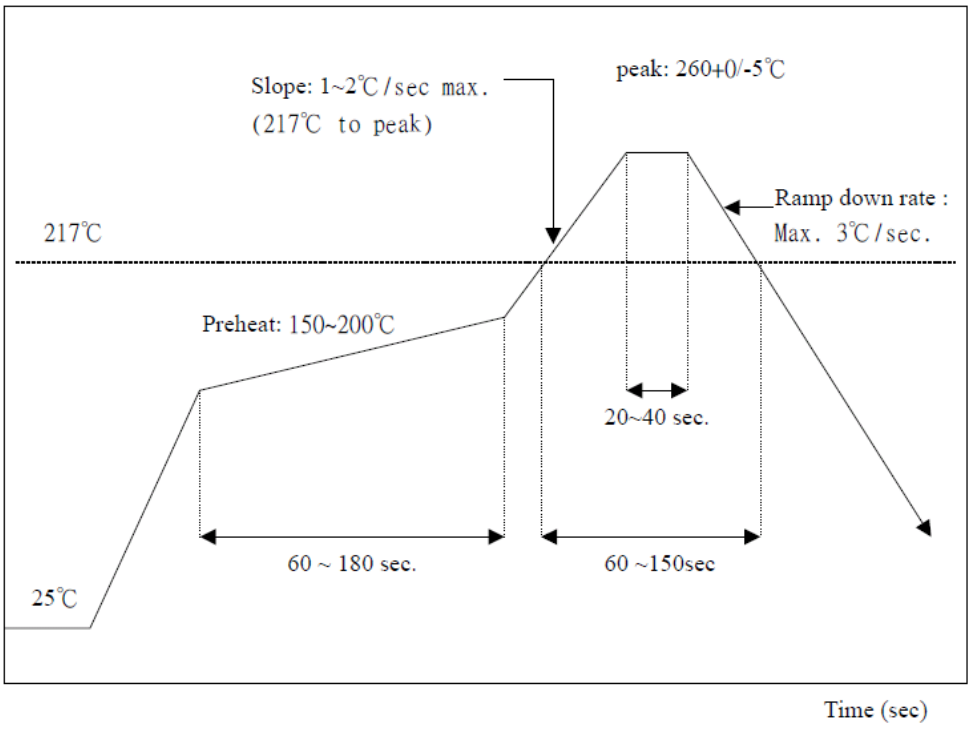


Figure 6 - Pb-free process - package peak reflow temperatures

	Symbol	Value
Preheat min. temperature	T_{smin}	150°C
Preheat max. temperature	T_{smax}	200 °C
Preheat duration	ts	60 to 180 seconds
Melting point	T_L	217°C

Time above melting point T_L	t_L	60 to 150 seconds
Peak temperature	T_p	260+0/-5°C
Time within 5°C to the peak temperature	tp	20 to 40 seconds
Ramp-up rate (T_{smax} to T_p)		3°C / second max.
Ramp-down rate	Average ramp-up rate (217℃ to peak): 1~2℃/sec max.	6°C / second max.
Note: According to JEDEC J-STD-020C. TB0S2B is qualified with 260°C max. peak temperature, temperature being measure on top of the shielding.		

Table 5 - Pb-free process - package peak reflow temperatures

10 Packaging

The TBS02B modules are packaged in 5 x 5 ESD blister trays.

The packaging include dry pack dessicant and humidity indicator in accordance JSTD 033

Outline dimensions: 165 mm x 140 mm x 9 mm

X-Grid: 30 mm

Y-Grid: 25 mm

Figure 7 – Module tray

11 ESD Safety

TBS02B is a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Follow guidelines as per EIA/JESD22-A115-A.

12 RoHS Compliance

TBS02B products are compliant with the European Union Directive 2002/95/EC Restriction on the Use of Hazardous Substances (RoHS). All designated products have Pb-free terminals.

13 Ordering Information

Part Number	**Description**
TBS02B	SDI-12 / Analog interface, 19 x 18 x 3 mm

12 History

Version	Date	Author	Changes
V1.0	17.11.2013	Mayerhofer	Creation of the document