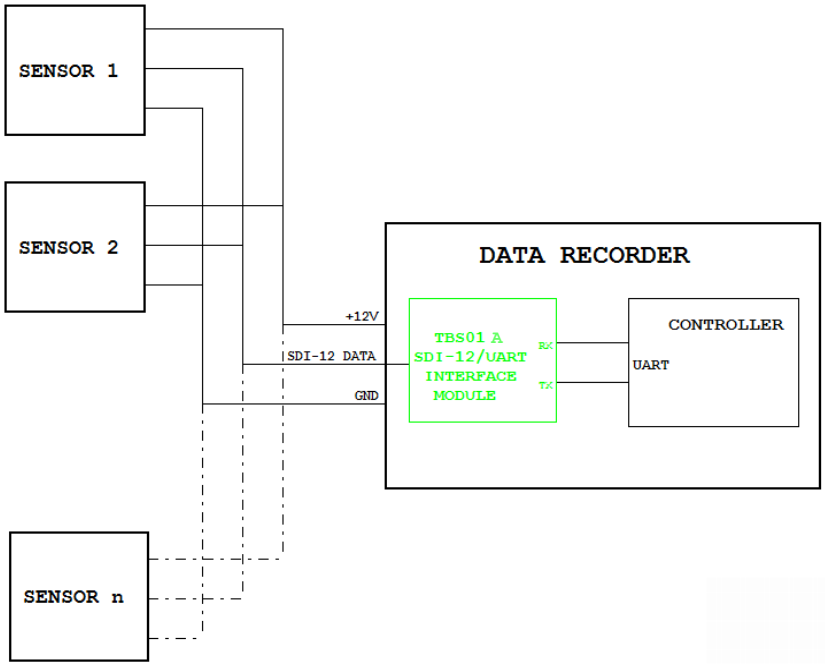
V1.4

Datasheet TBS01A

SDI-12 / UART Interface Module

The TBS01A SDI-12 / UART module is a bi-directional interface for the conversion of commands and data into SDI-12 format and vice versa. The module is Plug and Play, targeting cost sensitive data logging applications. It offers low current consumption, small footprint and easy integration into 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 UART interface module.
The TB01 contains all the necessary components of a complete SDI-12 interface. It includes a SDI-12 front-end, controller, crystal and passive components.
The TBS01A has been engineered specifically for applications where cost, performance, time to market and ease of integration are prime considerations. The TBS01A is a functionally and mechanically compatible replacement of the TBS01 module.



TBS01A module application

Features

- SDI-12 / UART Interface
- SDI-12 Standard V1.3
- Selectable data rate:
  4800, 9600, 19200, 38400 Baud
- Plug and Play
- Power Down Mode
- 3.3V UART interface
- 3.3V, 5V supply voltage
- 23 mm x 18 mm SMT module
- 2.3 mm module thickness
- Operating Temperature Range:
  -40°C - +85°C

Target Applications

- SDI-12 Data Logger
- SDI-12 / RS232 Interface
- SDI-12 / USB Interface

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 on 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 web site of the SDI-12 Support Group. More information on SDI-12 is presented in chapter 6.

The TBS01A module implements all the needed functions for interfacing an SDI-12 data line with a UART.
It is a plug and play solution for the design of SDI-12 compatible products.

1.1 Product Features

The TBS01A is based on a low power controller and robust SDI-12 interface hardware:

- 5V, 1200 baud SDI-12 data interface with transient protection
- 3,3V UART interface
- Selectable UART data rate: 4800, 9600, 19200, 38400 baud,(8 bits data, no parity, 1 stop bit, no handshake)
- 3,3V control interface
- Power Down Mode
- 3,3V, 5V supply voltage
- Operating temperature range: -40 - +85°C

The TBS01A is a fully compatible replacement of the TBS01 module.

2 Block Level Diagram

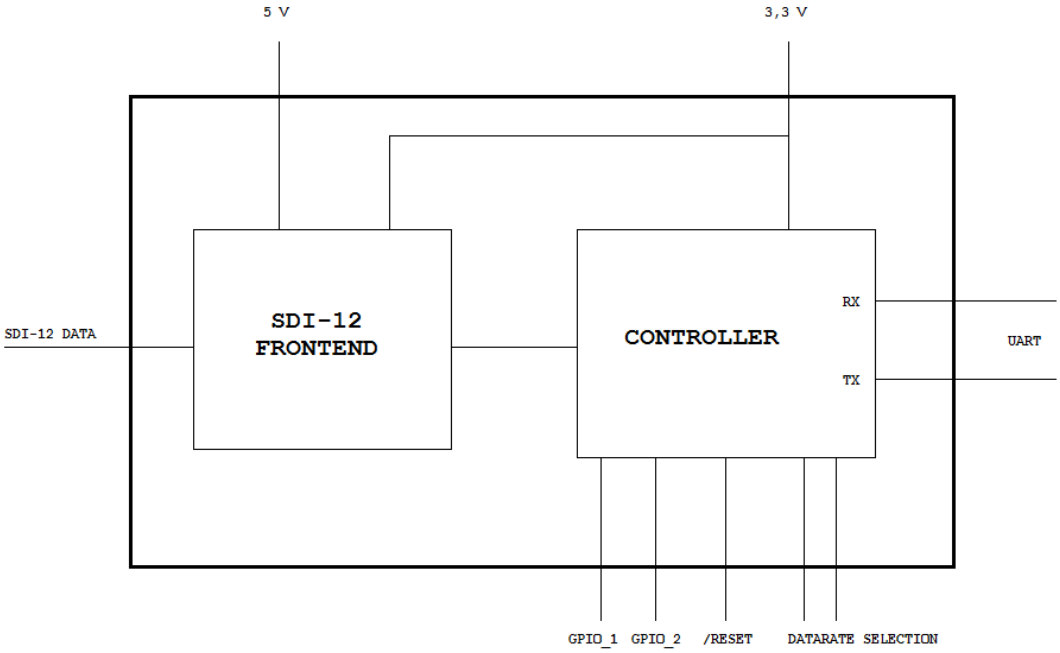


Figure 1 –TBS01A Block Diagram

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 TBS01A is connected to the TX output of the data recorder controller UART and converts the command strings to the logic levels and baud rate specified by the SDI-12 standard. Furthermore, the TBS01A module handles breaks, marks and all other details of the SDI-12 protocol.

Upon receiving data or status information originated by a Sensor, the TBS01A extracts the corresponding ASCII strings and presents it to the RX input of the data recorder controller UART.

3.2 Power Supplies

A TBS01A module can operate from a single 3.3V VCC supply and a 5V SDI-12 data interface supply. External decoupling capacitors and ferrite beads are recommended. (Refer to application schematic example, Figure 6)

In addition, the SDI-12 interface requires a 12V line to provide supply voltage for sensors. The sensor supply voltage has to be provided by the application hardware.

4 Pin Assignment and Description

4.1 Pin List

This table shows the pin names, their type (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	SDI-12_DATA	DI		5V	SDI-12 Serial Data Interface
2	GND_1				Ground
3	VCC_3V3	P		3V3	Main power supply
4	GND_2				Ground
5	VCC_5V	P		5V	SDI -12 data interface power supply
6	GND_3				Ground
7	BAUD_RATE_1	DI		3V3	Baud rate select [1]
8	BAUD_RATE_0	DI		3V3	Baud rate select [0]
9	NRST	DI	PU	3V3	Module Reset
10	GND_4				Ground
11	NC_1				Do not connect
12	GPIO_1	DO		3V3	General purpose output
13	GPIO_2	DI		3V3	WakeUp input
14	GND_5				Ground
15	RXD	DI	PU	3V3	Serial port (UART) receive line
16	TXD	DO		3V3	Serial port (UART) transmit line
17	NC_2				Do not connect
18	GND_6				Ground

Table 1 – Pin list

4.2 Module Pin Descriptions

4.2.1 SDI-12 Serial Data Interface – SDI-12_DATA

Bi-directional serial data interface port. SDI-12_DATA is low in idle state.

4.2.2 Baud Rate Select – BAUD_RATE[1:0]

Baud_Rate[0]	Baud_Rate[1]	Baud Rate
0	0	4800 baud
0	1	9600 baud
1	0	19200 baud
1	1	38400 baud

Table 2 - Baud Rate Select

UART setting : Baud rate, 8 databits, parity none, 1 stopbit, handshake none.

When connecting any Baud Rate Select Pin to VCC_3V3, use 100K Pull Up resistors.

4.2.3 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.

4.2.4 General Purpose Output – GPIO_1

Do not connect this pin.

4.2.5 General Purpose Input – GPIO_2 – WakeUp

If GPIO_2 is tied to 3.3V, the module will be continuously active, consuming 7mA current from the 3.3V supply line. For power saving reasons, it is recommended to control this Pin through a GPIO of the data logger controller. 1ms before accessing the module UART, GPIO_2 shall be set to HIGH to wake up the TBS01A. After finishing SDI-12 access, GPIO_2 shall be set to LOW. Current consumption will then decrease to 30µA.

4.2.6 NC_1, NC_2

Do not connect this pins.

4.2.7 SDI-12 Data Interface Supply Voltage – VCC_5V

Positive 5V supply voltage.

4.2.8 Main Module Supply Voltage – VCC_3V3

Positive 3,3V supply voltage.

4.2.9 Serial Port Interface Input/Output – TXD, RXD

TXD and RXD are the output and input of the UART port used for communication with the data recorder. RXD is configured with an internal pull-up.

3.3V logic levels; Baud rate according settings of Pin 6/7; 8 databits, no parity, 1 stopbit, no handshake

Example:

ASCII data:

TBS01A: Upon transmitting `0I! <CR><LF>` to the UART IF, the sensor will respond with the sensor ID:

Sensor response: `013TEKBOXVNTBS2PA0.6000001<CR><LF>`

Hex data:

TBS01A: transmit `30 49 21 0D 0A`

Sensor response: `30 31 33 54 45 4B 42 4F 58 56 4E 54 42 53 32 50 41 30 2E 36 30 30 30 30 30 31 0D 0A`

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	4.6	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 3 - 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 (GPIO_2 = HIGH)						
I_3V3	Supply current to pin VCC_3V3			5.5	7	mA
I_5V	Supply current to pin VCC_5V			20	400	µA
Supply Currents in sleep mode (GPIO_2 = LOW)						
I_3V3	Supply current to pin VCC_3V3			10	15	µA
I_5V	Supply current to pin VCC_5V			20	30	µA
Digital Inputs/Outputs						
Vil	Input low voltage level		-0.3V	0	0.9	V
Vih	Input high voltage level		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
SDI-12 Interface						
Vil	Input low voltage level		-0.5V	0	1	V
Vih	Input high voltage level		3.5	5	5.5	V
Operating temperature range			-40 to +85			°C

Table 4 - Electrical Specifications

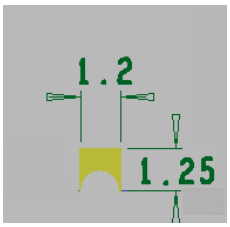
6 Power Management

TBS01A wakes up upon setting GPIO2 to HIGH. If there is no activity on the UART, set GPIO2 to LOW to return into sleep mode.

7 Mechanical Specifications, Pining

5.1 Package outline and recommend layout

5.1.1 Pad Dimensions



(Viewed from top)

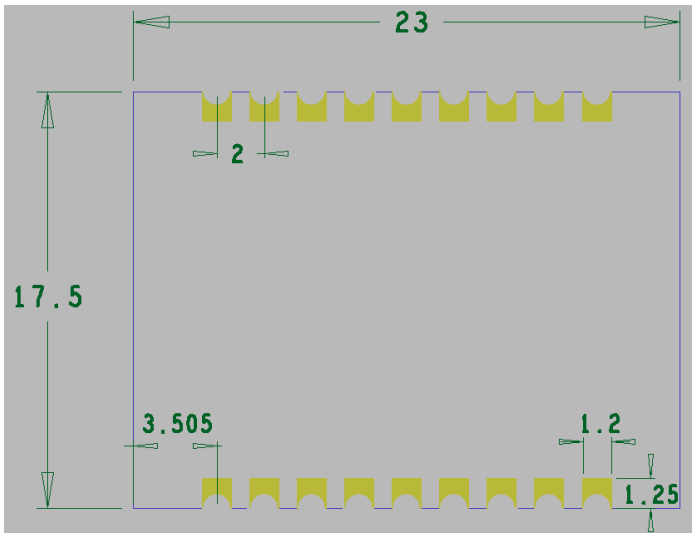
Figure 2 - Pad Dimensions

Pad Dimension Table

PAD type	Qty	Pad dimension
Edge plated pads	18	1.2 x 1.25mm

5.1.2 Package Dimensions

Dimensions are in mm



(Viewed from top)

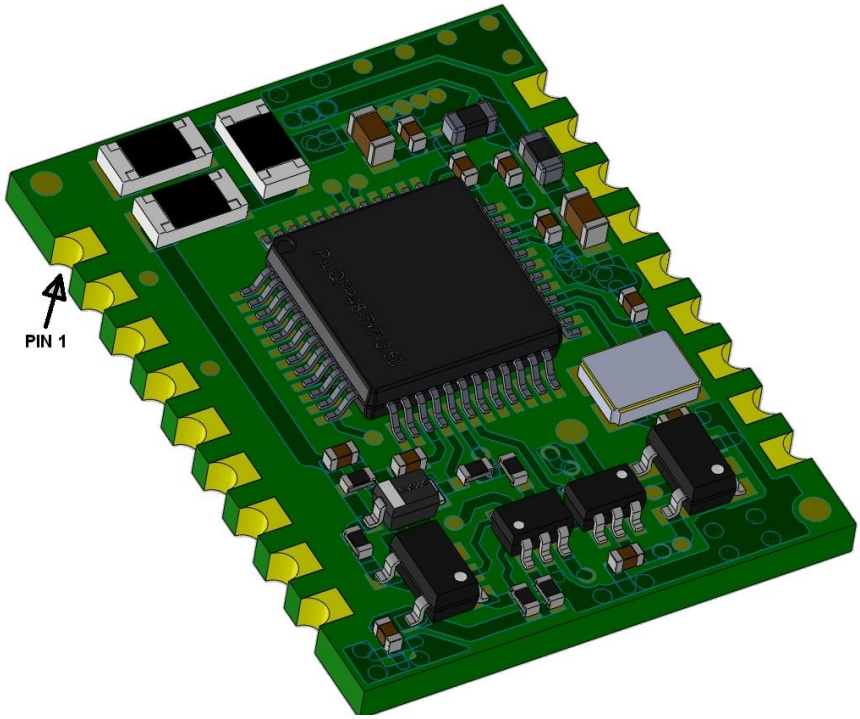
Figure 3 - Footprint Dimensions

Recommended PCB Pad dimension: 1.2 x 2 mm

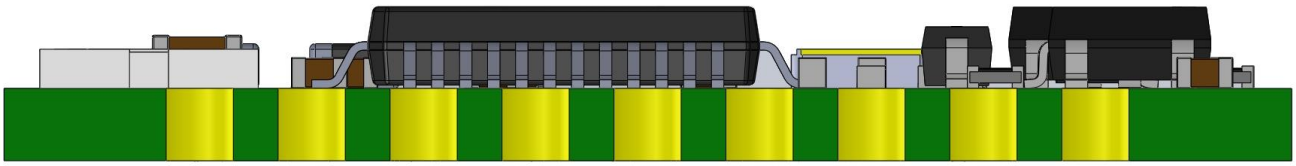
Module thickness (height): 2.3 mm

Pin centre Location Table

PIN_ NO.	PIN_X	PIN_Y
1	8.00	8.75
2	6.00	8.75
3	4.00	8.75
4	2.00	8.75
5	0.00	8.75
6	-2.00	8.75
7	-4.00	8.75
8	-6.00	8.75
9	-8.00	8.75
10	-8.00	-8.75
11	-6.00	-8.75
12	-4.00	-8.75
13	-2.00	-8.75
14	0.00	-8.75
15	2.00	-8.75
16	4.00	-8.75
17	6.00	-8.75
18	8.00	-8.75



(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 SDI-12 Basics

SDI-12 is a serial data communication standard for interfacing multiple sensors with a data recorder The SDI-12 uses a shared bus with 3 wires: power (12V), data, ground
Data rate: 1200 baud

Each sensor at the bus gets a unique address which is in the range ASCII [0-9, a-z, A-Z]. The default address of every sensor is ASCII[0]. When setting up a SDI-12 sensor network, every sensor needs to be configured with a unique address. This can be done using the *"Change Address Command"*.

A sensor typically can measure one or more parameters. Sensor manufacturers usually specify *"Extended Commands"* to configure or calibrate sensors. These commands are specified by the manufacturer, but they follow the command structure specified by SDI-12.

A typical recorder/sensor measurement sequence proceeds as follows:
1) The data recorder wakes all sensors on the SDI-12 bus with a break.
2) The recorder transmits a command to a specific, addressed sensor, instructing it to make a measurement.
3) The addressed sensor responds within 15.0 milliseconds returning the maximum time until the measurement data will be ready and the number of data values it will return.
4) If the measurement is immediately available, the recorder transmits a command to the sensor instructing it to return the measurement result(s). If the measurement is not ready, the data recorder waits for the sensor to send a request to the recorder, which indicatesthat the data are ready. The recorder then transmits a command to get the data.
5) The sensor responds, returning one or more measurement results.

SDI-12 command structure:
Each SDI-12 command is an ASCII string with up to 5 characters, starting with the sensor address and terminated by a **!** character.

Example:
Send Identification Command **0I!**
0 is the sensor address (sensor zero). Upon receiving this command, the sensor will send an ASCII string containing sensor address, a SDI-12 compatibility number, company name, sensor model number, sensor version number and sensor serial number.

The standard process to carry out a measurement is to send a measurement request upon which the sensor responds with the time that is required to carry out the measurement and the number of data items being returned. After waiting the time that the sensor requires to carry out the measurement, the data recorder sends a *"Read Command"* to get the measurement results.

Example:
Start Measurement Command **0M1!**
Sensor 0 might respond 00302 which means the measurement will take 30 seconds and deliver 2 values.
After min. 30 seconds, the data recorder can send the Read Data Command **0D0!** to which Sensor 0 might reply 0+27+1050. +27+1050 is the two measurement results which may be 27°C and 1050 milibar.
The response string of a sensor is always in ASCII format and may contain up to 40 or up to 80 characters, depending on the type of command. Out of 40 or 80 characters, the values part of the response string may contain up to 35 or 75 characters.
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7 Application Information

7.1 Application Circuit, SDI-12 / UART Interface

The schematic shows an example application of the TBS01A as an SDI-12 / UART interface.

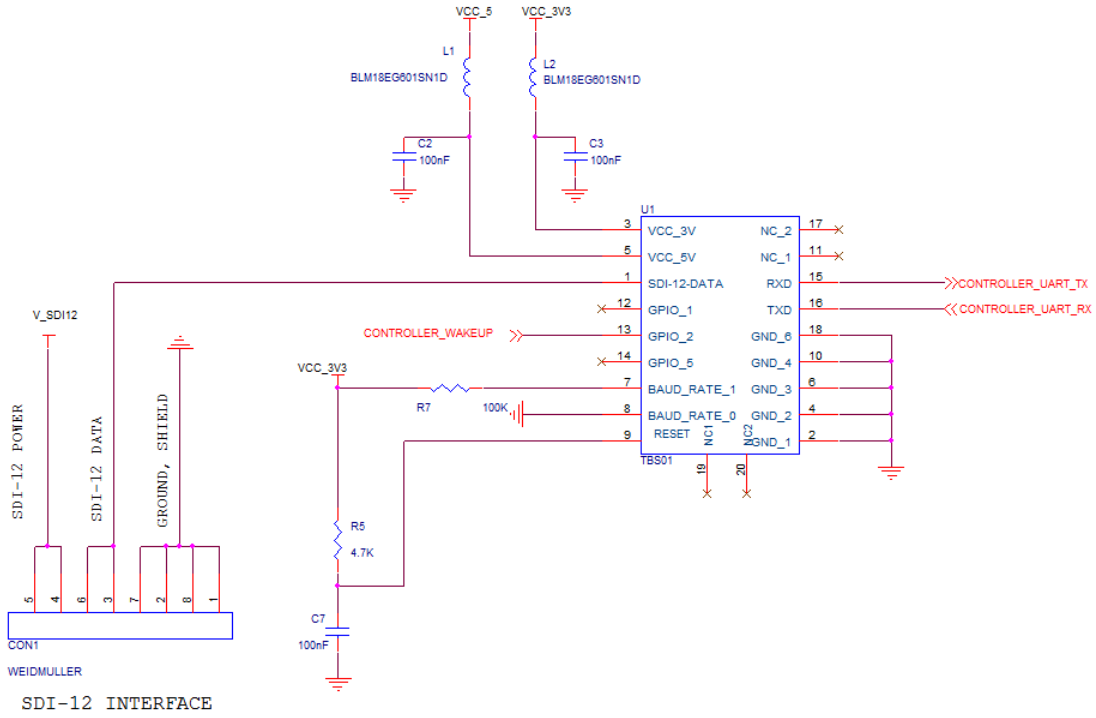

Figure 5 – Standard Application Example

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 5 - Environmental Specifications

9 Soldering Profile

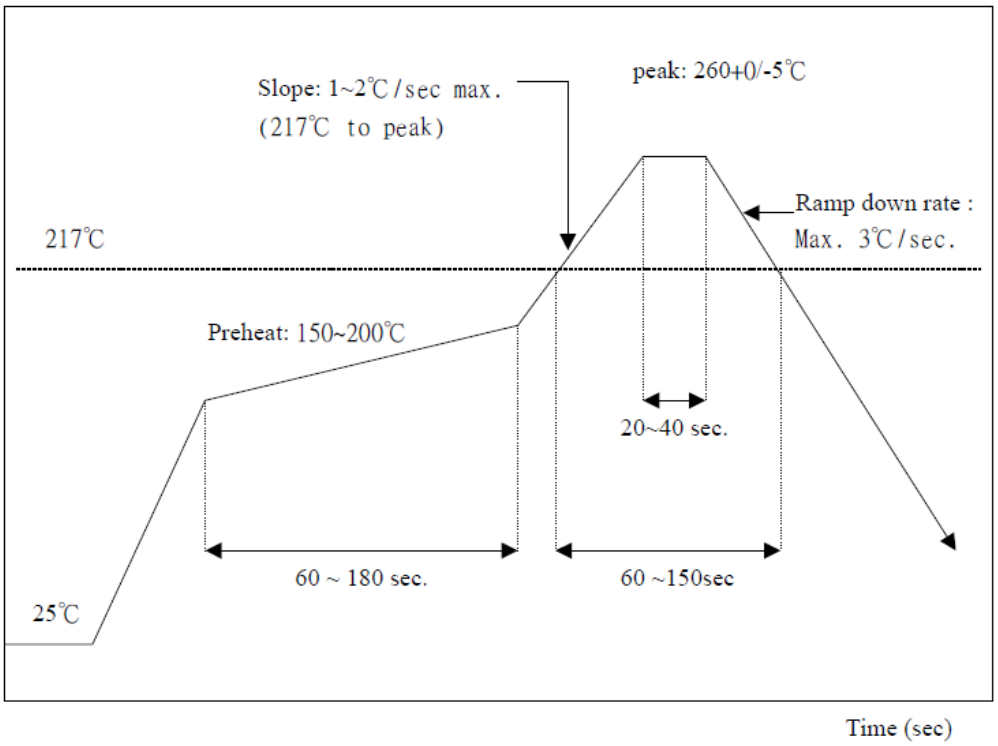

Figure 6 - Pb-free process - package peak reflow temperatures

	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. TBS01A is qualified with 260°C max. peak temperature, temperature being measure on top of the module.		

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

10 Packaging

The TBS01A 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

The TBS01A 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

TBS01A modules 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
TBS01A	SDI-12 / UART interface 23 x 18 x 3 mm

12 History

Version	Date	Author	Changes
V1.0	02.07.2013	Michael Mayerhofer	Creation of the document
V1.1	17.11.2013	Michael Mayerhofer	Update of chapter 10
V1.2	03.06.2013	Michael Mayerhofer	Update of chapter 4.2.9
V1.3	26.08.2020	Michael Mayerhofer	Matched pictures with HW REV C
V1.4	17.02.2022	Michael Mayerhofer	Updated Table 1