Datasheet TBS05A

UART / SDI-12 Interface Module

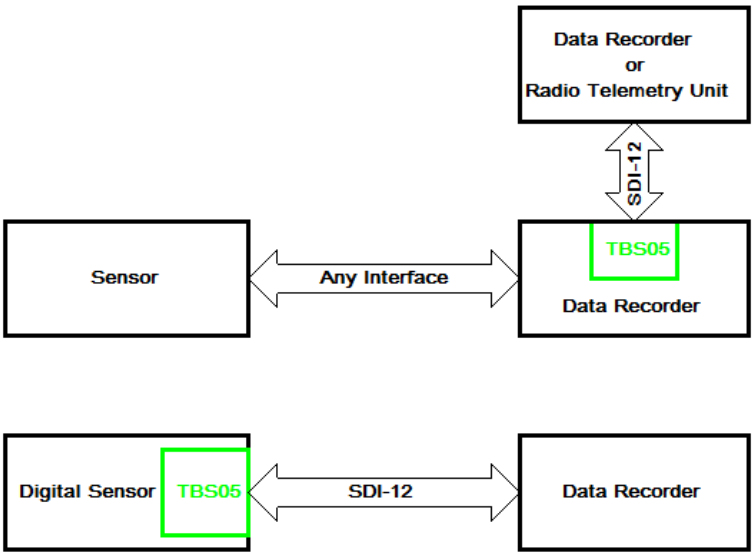
The TBS05AUART / SDI-12 module is an interface which can be used to add a SDI-12 slave interface to digital sensors. The module is Plug and Play, targeting cost sensitivedata logging applications. It offers low current consumption, small footprint and easy integration into products which require a SDI-12 interface.

The TBS05Ais a SDI-12 slave interface for digital sensors. The sensor can write up to 10 measurement values into the SRAM of the TBS05A, which then can be queried over the SDI-12 interface from a SDI-12 master.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 TBS05A contains all the necessary components of a complete SDI-12 interface. It includes SDI-12 front-end, controller, crystal and passive components.

The TBS05A has been engineered specifically for applications where cost, performance, time to market and ease of integration are prime considerations.

TBS05A Applications



Features

- UART / SDI-12 Slave 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 18mmSMT footprint
- 2.3 mm module thickness
- Operating TemperatureRange:
  - 40°C … + 85°C

Target Applications

- SDI-12 Interface for digital sensors
- SDI-12 Data Logger Slave Interface
- UART / SDI-12 Slave Interface

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1 Introduction

SDI-12 is a standard for interfacing SDI-12 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 website of the SDI-12 Support Group. (More information on SDI-12 is presented in chapter 6.)

The TBS05Amodule implements all the needed functions for interfacing a UART with a SDI-12 data line.
It is a Plug and Play solution for the design of SDI-12 compatible products.

1.1 Product Features

The TBS05Ais based on a low power controller and robust SDI-12 interface hardware:

- 5V, 1200 baud SDI-12 slave data interface with transient protection
- 3,3V UART interface
- Selectable UART data rate: 4800, 9600, 19200, 38400 baud(8 data bits, 1 stop bit and even parity)
- 3,3V control interface
- Power Down Mode
- 3,3V, 5V supply voltage
- Operating temperature range: -40 - +85°C

The TBS05A is a mechanically and electrically compatible replacement of the TBS05. The TBS05A is a firmware variant of the TBS01A; hardware wise it is identical.

2 Block Level Diagram

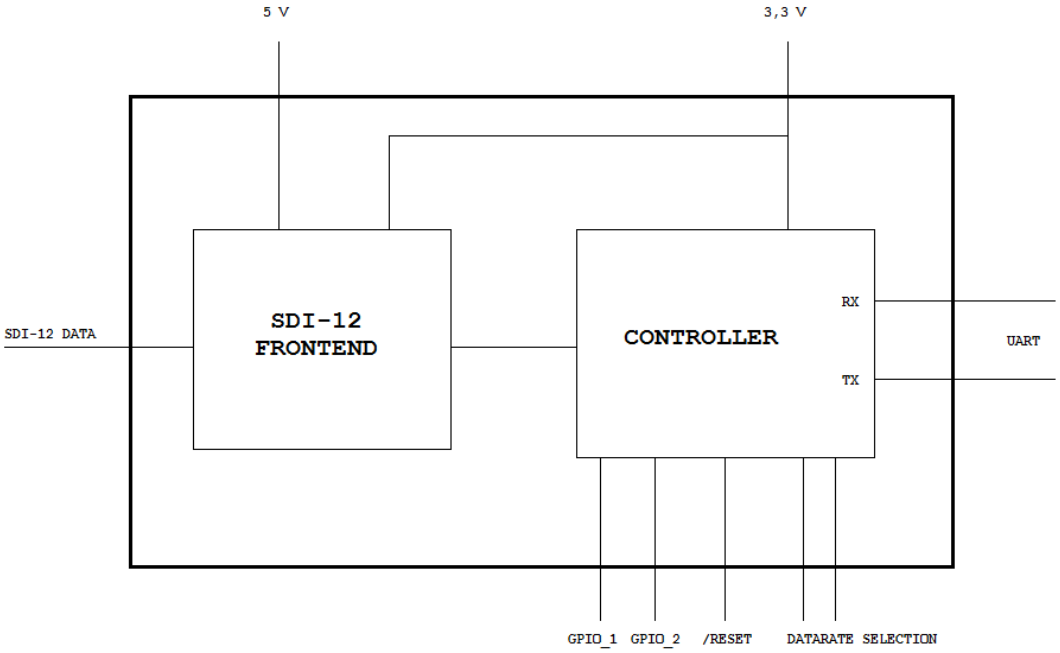


Figure 1 –TBS05ABlock Diagram

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 TBS05Ais connected viaa SDI-12 interface to a suitable data logger on one side and to the UART of a controller on the other side. The UART of the controller can send up to 10 different measurement values to the UART interface of the TBS05A.The datalogger can retrieve stored measurement values from the TBS05A at any time, using standard SDI-12 commands.

3.2 UART data exchange format

Data communication is according to RS232 standard with 9600 baud, 8 data bits, 1 stop bit and even parity.

Data communication uses a generic protocol. The following command structures are supported.

TBS05A supports the following command for writing data into the TBS05A SRAM via UART. The index refers to the corresponding measurement value.

Cmd, Byte 1	*Length, Byte 2*	*Index, Byte 3*	*Payload, Byte 4-7*	*Checksum N + 1*

0x02 = write DATA to SRAM	5	0-9	IEEE 754 Float / Big Endian	XOR over bytes 1 to 2 + N

Table 1 - Request Format (Controller ->TBS05A)

See also chapter 4.2.9 for an example.

Further commands can be implemented for customized variants of TBS05A upon customer request – for example:

Cmd, Byte 1	*Length, Byte 2*	*Payload, Byte 3 - N*	*Checksum N + 1*
Command	Length 0 – 32	Up to 32 Bytes payload	XOR over bytes 1 to 2 + N

Table 2 - Request Format (Controller ->TBS05A)

Status	*Length*	*Checksum*
ACK = 0	0	XOR over bytes 1-2

Table 3- Response Format ACK (TBS05A -> controller)

Status	*Length*		
ACK = 0	Length 0 – 32	Up to 32 Bytes payload	XOR over bytes 1 to 2 + N

Table 4 - Response Format ACK with Data (TBS05A -> controller)

Status	*Length*	*Code*	*Checksum*
NACK = 1	1	0 – 0xFF	XOR over byes 1-3

Table 5 - Response Format NACK (TBS05A -> controller)

3.3 SDI-12 Interface

TheTBS05A module works like a SDI-12 Slave.

The implemented SDI-12 standard is V1.3.

The SDI-12 slave interface supports up to 10 measurement values. Each value is stored internally as a floating point number. For NaN signaling the value 9999999 is used.

The time returned for the SDI-12 „Start measurement command“ (and similar commands) is 000. The SDI-12 module therefore always claims that data is immediately available.

For the SDI-12 command „Send Identification Command” the sensor returns “a12TEKBOX05000001001YYKWXXXX”. The vendor identification is “TEKBOX05”, the sensor model number “000001” and the version is “001”. The serial number is YYWWXXXX where YY is the year, WW is the week of the year and XXXX is a unique sequence for this week. The ID can be customized upon customer request.

The implementation for 10 measurement values is done by supporting the *“Measurement Command aM!”* and the Additional Measurement Commands aM1!, …, aM9!“. In total the slave supports therefore 10 data points.

Default module address is “0”.

3.4 Supported SDI-12 commands

aM!	aMC!	aC!	aCC!	get value from register 0
aM1!	aMC1!	aC1!	aCC1!	get value from register 1
aM2!	aMC2!	aC2!	aCC2!	get value from register 2
aM3!	aMC3!	aC3!	aCC3!	get value from register 3
aM4!	aMC4!	aC4!	aCC4!	get value from register 4
aM5!	aMC5!	aC5!	aCC5!	get value from register 5
aM6!	aMC6!	aC6!	aCC6!	get value from register 6
aM7!	aMC7!	aC7!	aCC7!	get value from register 7
aM8!	aMC8!	aC8!	aCC8!	get value from register 8
aM9!	aMC9!	aC9!	aCC9!	get value from register 9

Following commands are supported by TBS05A:

Command	Description	Response
a!	Acknowledge Active	a<CR><LF>
aI!	Send Identification	allccccccccmmmmmmmvvvxxxxxxxxxxxxx<CR><LF> Identification information
aAb!	Change Address	b<CR><LF> Changing the probe sensor address
?!	Address Query	a<CR><LF>
aM!	Start Measurement	atttn<CR><LF> Delay (ttt) in seconds and number of values (n) up to 9
aMn!	Additional Measurement	atttn<CR><LF> Delay (ttt) in seconds and number of values (n) up to 9
aMC!	Start Measurement and Request CRC	atttn<CR><LF> Delay (ttt) in seconds and number of values (n) up to 9
aMCn!	Additional Measurement and Request CRC	atttn<CR><LF> Delay (ttt) in seconds and number of values (n) up to 9
aC!	Start Concurrent Measurement	atttnn<CR><LF> Delay (ttt) in seconds and number of values (nn) up to 20
aCn!	Additional Concurrent Measurement	atttnn<CR><LF> Delay (ttt) in seconds and number of values (nn) up to 20
aCC!	Start Concurrent Measurement and Request CRC	atttnn<CR><LF> Delay (ttt) in seconds and number of values (nn) up to 20
aCCn!	Additional Concurrent Measurement and Request CRC	atttnn<CR><LF> Delay (ttt) in seconds and number of values (nn) up to 20
aDn!	Send Data	N up to 9
aV!	Start Verification	a0000<CR><LF> Not supported
aRn!	Continuous Measurement	a<CR><LF> Not supported
aRCn!	Continuous Measurement and Request CRC	a<CRC><CR><LF> Not supported

3.5 Power Supply

The TBS05Amodule 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)

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

#	Pin Name	Type	PU/PD	Domain	Description
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	DI	PU	3V3	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	DI	PU	3V3	Do not connect
18	GND_6				Ground

Table 6 – 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. The module is shipped with default address 0.

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 7 - Baud Rate Select

UART setting: 8 data bits, 1 stop bit and even parity

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 – GPIO

If GPIO_2 is tied to 3.3V, the module will be continuously active, consuming 7 mA current from the 3.3V supply line. For power saving reasons, it is recommended to control this Pin through a GPIO of the microcontroller which may be used to write data via the UART interface into the registers of the TBS05.At least 1ms before accessing the module UART, GPIO_2 shall be set to HIGH to wake up TBS05. After finishing UART access, GPIO_2 shall be set to LOW. Current consumption will then decrease to 30µA. On the SDI-12 side, no power management needs to be implemented. The TBS05 wakes up as soon as it receives any SDI-12 command.

4.2.6 NC_1, NC_2

Do not connect this pin.

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. The TBS05 VCC_3V3 pin needs to be powered continuously to avoid losing the content of the measurement registers.

4.2.9 SerialPort 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.

Example:

Write a measurement value of 1357.234 into register 0:

Register 0 -> index byte = 0x00

Convert 1357.234 into a Hex value; e.g. use a converter such as for example:
http://www.h-schmidt.net/FloatConverter/IEEE754.html

1357.234 ≡ 0x44 0xA9 0xA7 0x7D

-> length byte ≡ 0x05 (index byte + 4 floating point bytes)

Calculate the checksum using by XOR all Bytes:

http://www.miniwebtool.com/bitwise-calculator/

->0x30

Send following data to the TBS05 via UART: 02 05 00 44 A9 A7 7D 30 (store 1357.234 to register 0)

TBS05A response, ACK: 00 00 00

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 8 - 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

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Vol	Output low voltage level	|Iol| = 2 mA			0.45	V
Voh	Output high voltage level	|Ioh| = 2mA	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

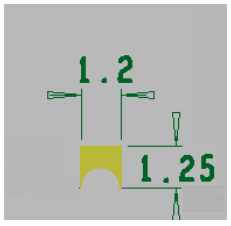
Table 9 - Electrical Specifications

6 Power Management

The TBS05Awakes up upon setting GPIO2 to HIGH or upon accessing the SDI-12 interface. If there is no activity on the UART, set GPIO2 to LOW to return into sleep mode. Any traffic accessing the SDI-12 interface will wake up the module automatically.

7 Mechanical Specifications, Pining

7.1 Pad Dimensions



(Viewed from top)

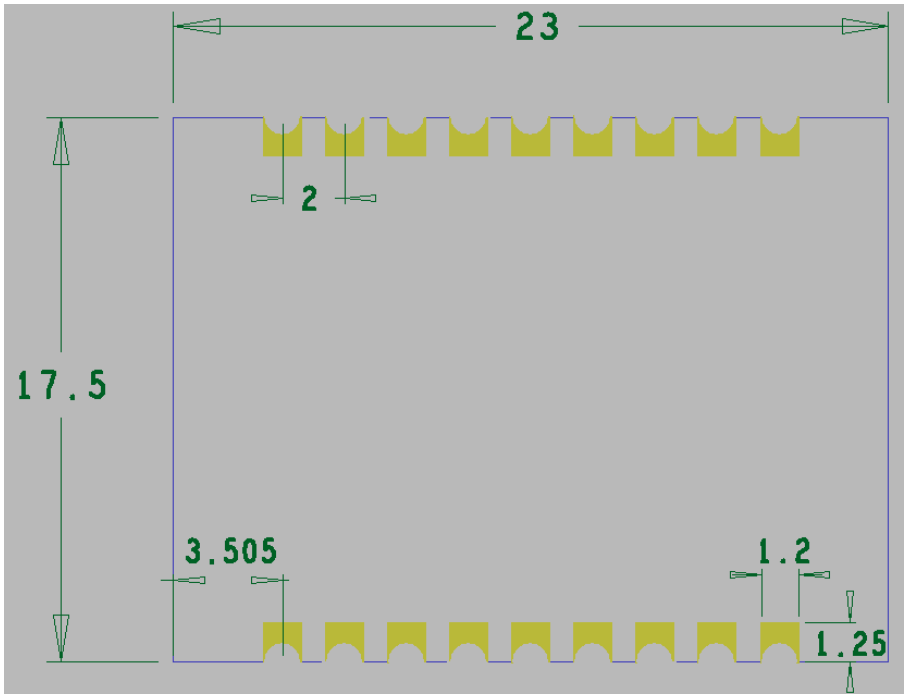
Figure 2- Pad Dimensions

Pad Dimension Table

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

7.2 Package Dimensions

Dimensions are in mm

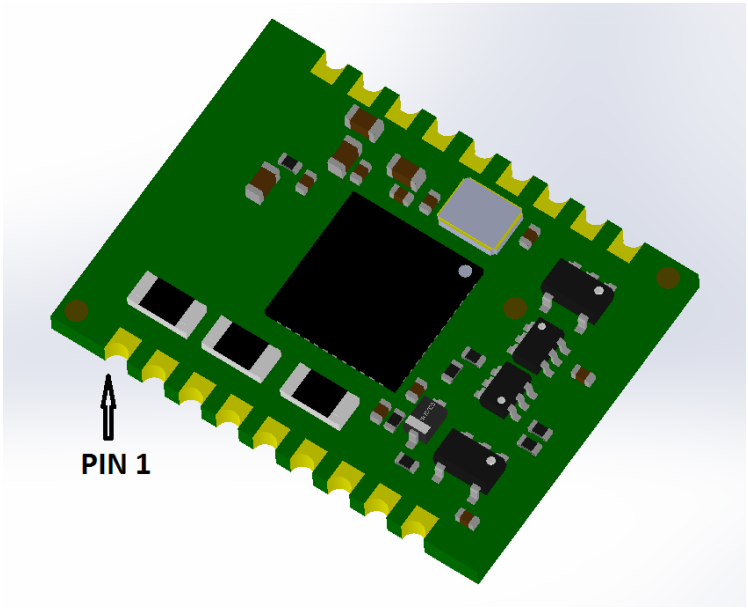


(Viewed from top)

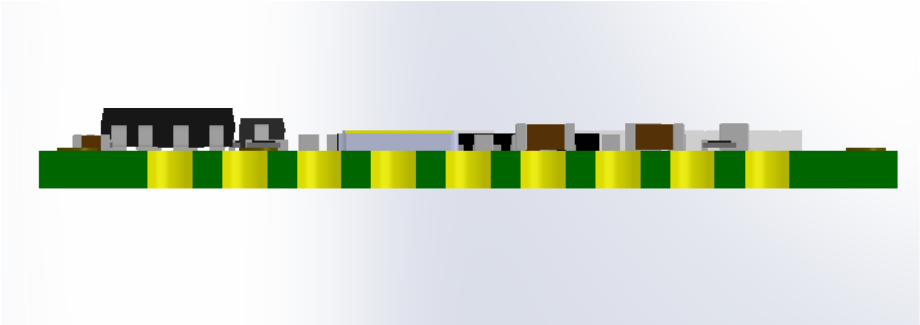
Figure 3- Footprint Dimensions
(Recommended PCB Pad dimension: 1.2 x 2 mm)

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

7.3 Marking description

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

8 SDI-12 Basics

SDI-12 is a serial data communication standard for interfacing multiple sensors with a data recorder
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. This 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, 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 **0M1!00302** which means the measurement will take 30 seconds and deliver two values. After min. 30 seconds, the data recorder can send the *"Read Data Command **0R1!"***to which Sensor 0 might reply **0R1!+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.Application Information

9 Application Circuit, SDI-12 / USB Interface

The schematic shows an example application of TBS05A as an SDI-12 slave interface. The UART interface of the module is connected to the UART of the sensor controller.

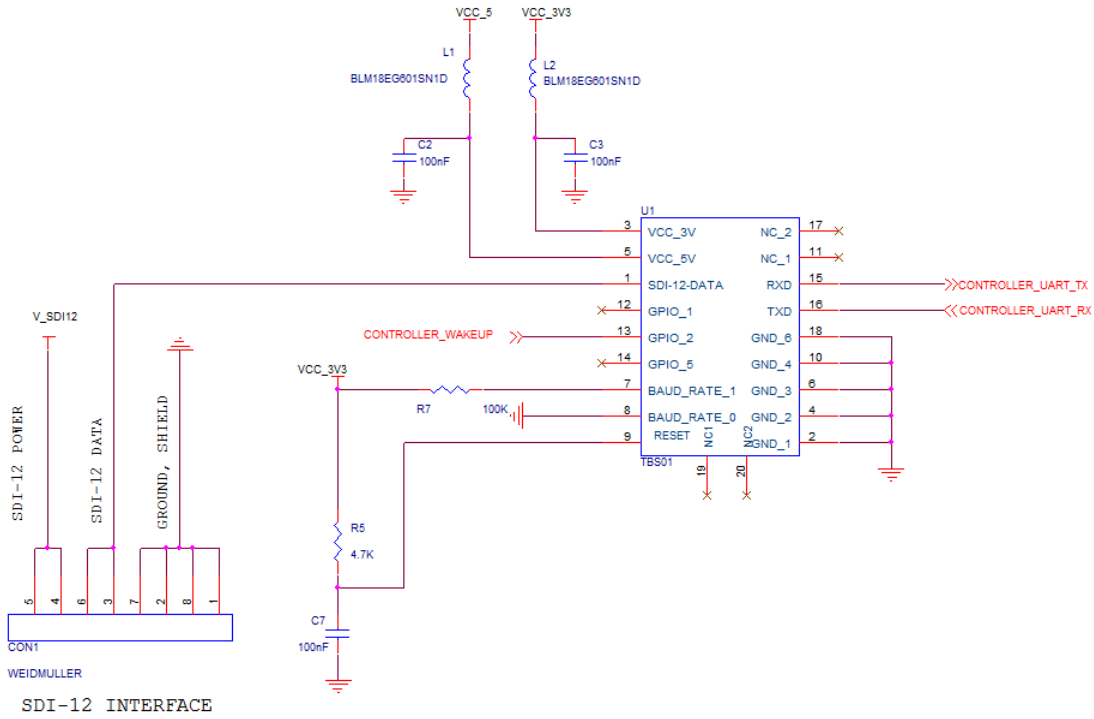


Figure 5 – Standard Application Example

10 Environmental Specifications

Symbol	Parameter	Conditions	Min	Max	Unit
T_A	Operating Ambient TemperatureRange		-40	+85	°C
T_{STG}	StorageTemperatureRange		-40	+85	°C
	Humidity level	Ta=60°C No condensation	-	95	% R.H

Table 10 - Environmental Specifications

11 Soldering Profile

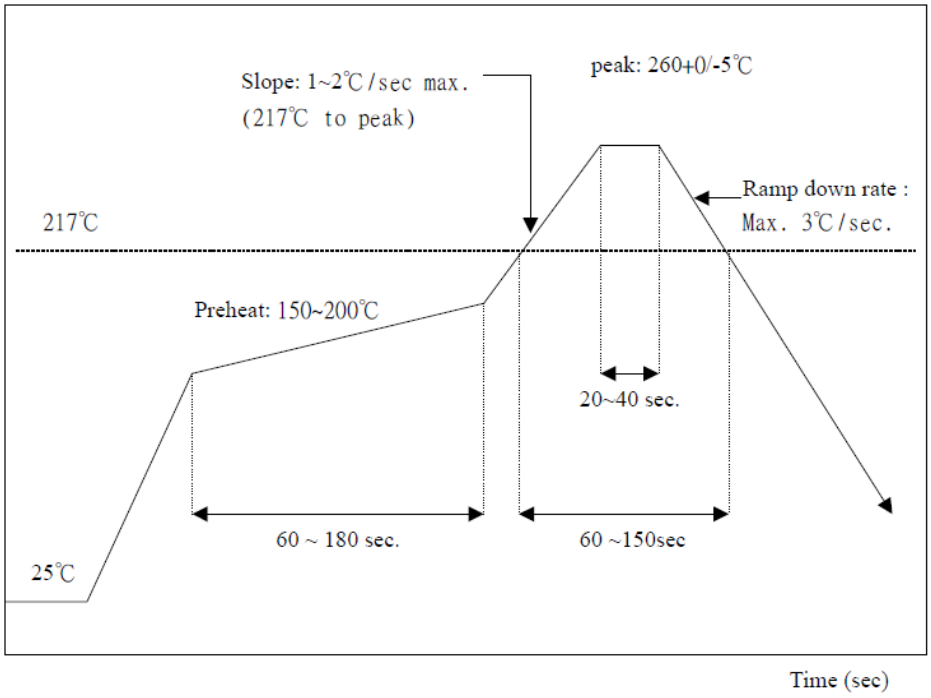


Figure 6 - Pb-free process - package peak reflow temperatures

	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. TB01is qualified with 260°C max. peak temperature, temperature being measure on top of the module.		

Table 11 - Pb-free process - package peak reflow temperatures

12 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

13 ESD Safety

The TBS05Ais a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Follow guidelines as per EIA/JESD22-A115-A.

14 RoHS Compliance

TBS05Amodules 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.

15 Ordering Information

Part Number	**Description**
TBS05A	UART / SDI-12 interface23 x 18 x 3 mm

16 History

Version	Date	Author	Changes
V1.0	03.08.2010	M. MAYERHOFER	Fig. 4 updated
V1.1	05.08.2010	M. MAYERHOFER	GPIO_2 updated
V1.2	20.02.2011	M. MAYERHOFER	formatting
V1.3	06.05.2011	M. MAYERHOFER	formatting
V1.4	01.03.2012	M. MAYERHOFER	updated SDI-12 commands table
V1.5	17.11.2013	M. MAYERHOFER	change from TBS05 to TBS05A
V1.6	03.06.2014	M. MAYERHOFER	updated chapters 4.2.5, 4.2.9