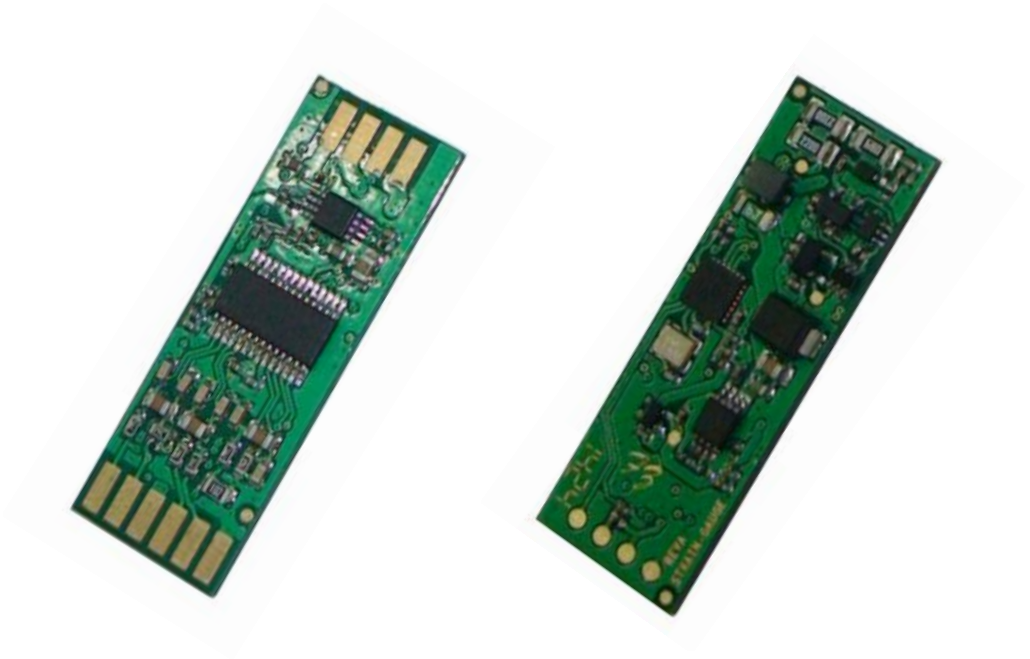
SDI-12 24 Bit Strain Gauge Interface

The TBSSG1 is a SDI-12 interface board for the connection of a strain gauge and a PT1000. The PCBA has dimensions of 40mm x 14mm x 5.4mm and is covered with conformal coating.
The TBSSG1 offers extended SDI-12 commands to set the amplifier gain and to linearize and temperature compensate the strain gauge output.



TBSSG1 SDI-12 Strain Gauge Interface PCBA

Features

- Differential input for strain gauges
- 5V drive output for strain gauge bridge
- PT1000 interface for temperature compensation
- Extended SDI-12 commands for scaling, linearization and temperature compensation
- 24 Bit ADC
- Programmable gain amplifier; Gain can be set via extended SDI-12 commands: 1, 2, 4, 8, ….64, 128
- 40mm x 14mm x 5.4mm PCBA dimension
- Conformal coating
- 6V-38V supply voltage range
- SDI-12 Standard V1.3
- Operating Temperature Range:
  - 40°C … + 85°C

Target Applications

- SDI-12 Sensor Networks

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1 Introduction

The TBSSG1 is a SDI-12 interface for strain gauge bridges and a PT1000. It is dimensioned to fit inside pressure sensor housings. It offers a 24 bit ADC, a differential input amplifier with programmable gains of 1, 2, 4, 8, 16, 32, 64, 128, a 5V drive output for the bridge, an input for a PT1000, 50/60 Hz line noise suppression and true background calibration.
Gain, linearization, temperature calibration and scaling can be controlled with extended SDI-12 commands
The device works with supply voltages in the range of 6V to 32V.

1.1 Measurement

Differential strain gauge input voltage range:
Following restrictions have to be considered with respect to the gain setting when working in differential mode:

VINP Positive Input	Input voltage range
Gain = 1-8, buffer ON	GND + 0.1 to 4.9V
Gain = 16 - 128, buffer ON	GND + 0.4 to 3.5 V
Gain = 1-8, buffer OFF	GND to 5V

VINN Negative Input	Input voltage range
Gain = 1-8, buffer ON	GND + 0.1 to 4.9V
Gain = 16 - 128, buffer ON	GND + 0.4 to 3.5 V
Gain = 1-8, buffer OFF	GND to 5V

This translates into following input voltage ranges (maximum swing of the strain gauge output Signal for maximum measurement resolution):

PGA setting	Maximum differential voltage at the strain gauge interface
Gain = 1	±4.8V
Gain = 2	±2.4V
Gain = 4	±1.2V
Gain = 8	±0.6V
Gain = 16	±192mV
Gain = 32	±96mV
Gain = 64	±48mV
Gain = 128	±24mV

1.2 Product Features

- Measurement of pressure (weight) and temperature
- PT1000 input for temperature compensation
- Linearization / scaling with a third order polynomial using extended SDI-12 commands
- Temperature compensation with a third order polynomial using extended SDI-12 commands
- Typ. 1 sec response time (see technical specifications in chapter6)

- <15mA current consumption during measurement
- 6 to 38V supply voltage range
- < 50µA idle current
- Reverse voltage and transient protection
- Dimensions: 40mm x 14mm x 5.4mm
- Conformal coating with Elpeguard from Peters Lacke
- Operating temperature range: -40 … +85°C

1.3 Calibration

Third order polynomials, with the polynomial coefficients configurable via an extended SDI-12 command are provided for scaling and compensation of non-linearity and for temperature compensation of the strain gauge bridge.

Furthermore there is an extended SDI-12 command for the 0°C calibration of the PT1000 interface

1.4 Installation

The TBSSG1 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

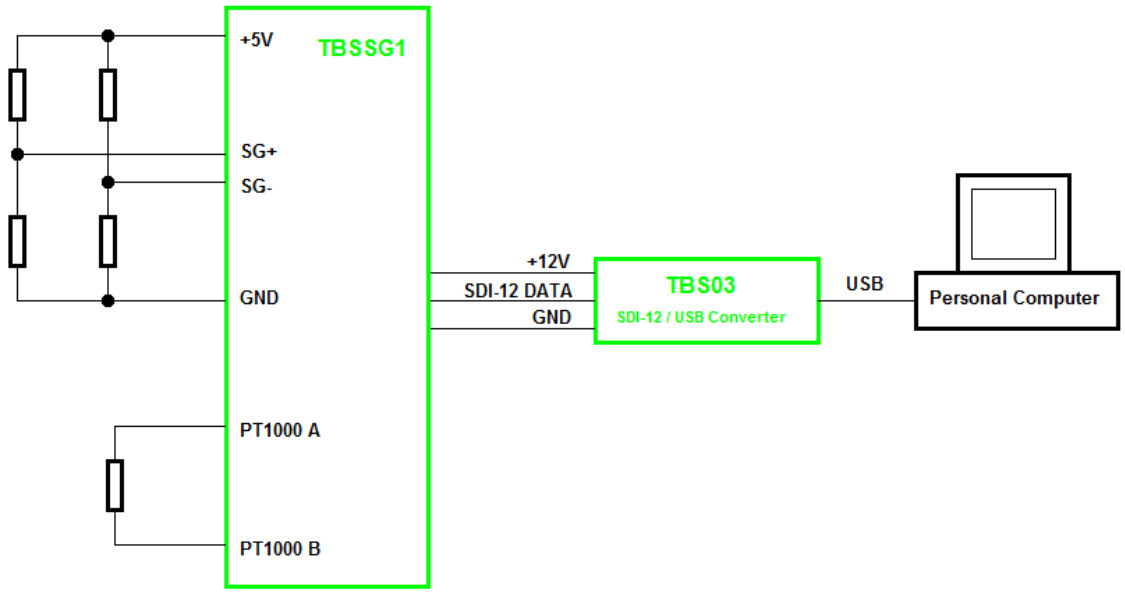

Figure 1 –TBSSG1 connected to TBS03 SDI-12 to USB converter; setup for controlling / testing sensors and for PC based data recording

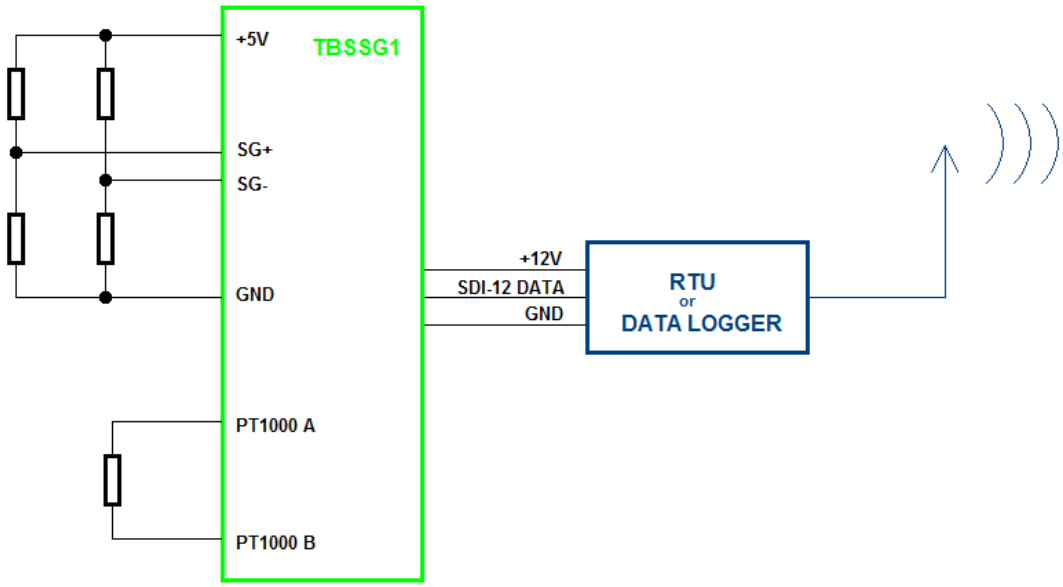

Figure 2 –TBSSG1 connected to to Remote Telemetry Unit or Data Recorder

3 PCBA Connections

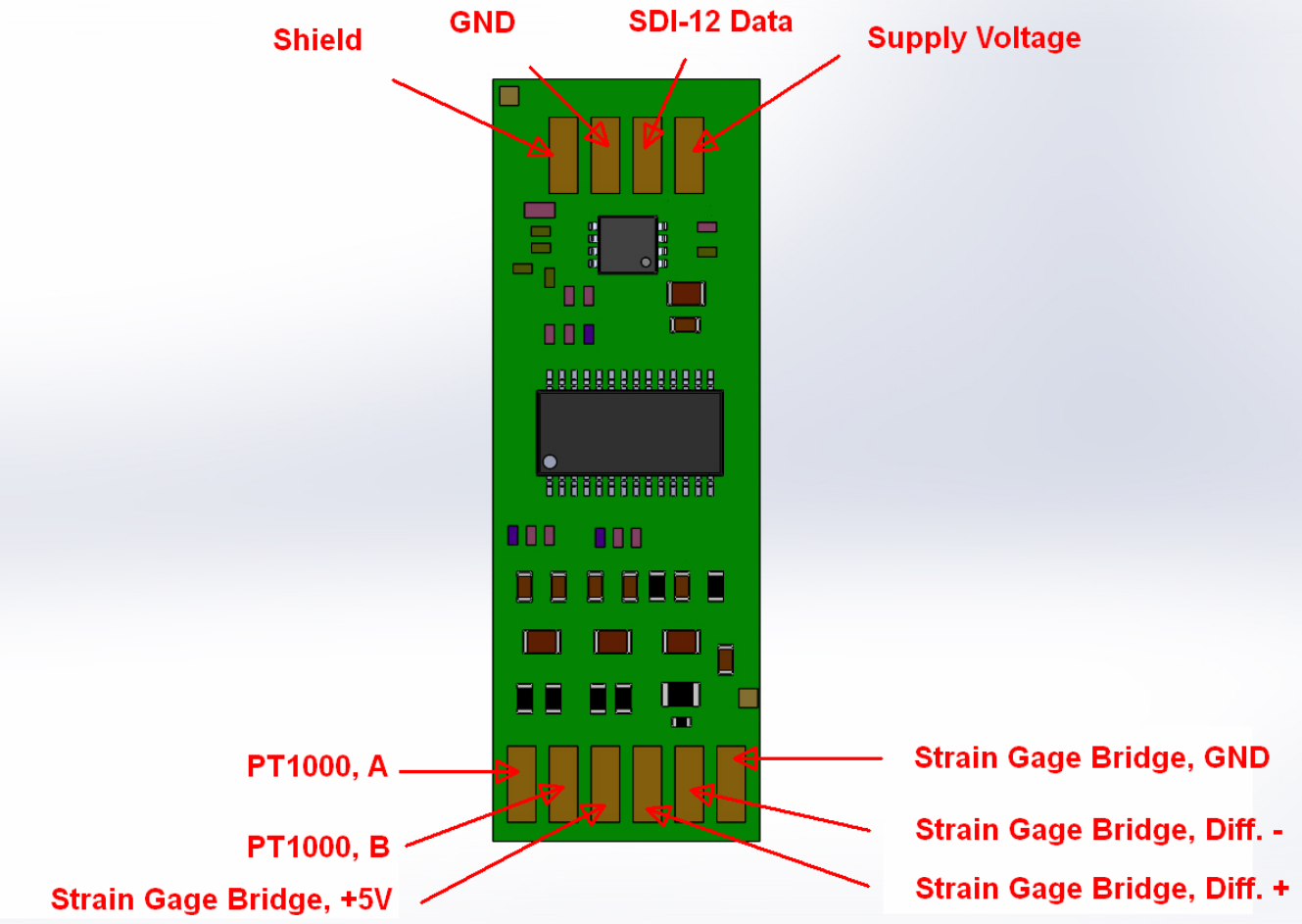

Figure 3 – Soldering pad connectivity

4 Pin pad row - 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
6-38V supply: connect to the positive supply voltage wire of the SDI-12 cable

6 Pin pad row - strain gauge bridge / PT1000 interface:

PT1000, A: connect to one terminal of the PT1000
PT1000, B: connect to the other terminal of the PT1000
Strain gauge bridge, +5V: connect to the top of the strain gauge bridge
Strain gauge bridge, +5V: connect to the differential + node of the strain gauge bridge
Strain gauge bridge, +5V: connect to the differential - node of the strain gauge bridge
Strain gauge bridge, GND: connect to the bottom node of the strain gauge bridge

4 Temperature compensation

The TBSSG1 provides a calibrated 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 1: *Temperature sensor characteristics*

Furthermore, for applications requiring higher accuracy, it provides connectivity for a PT1000.

The temperature compensation is based on a third order polynomial. The temperature compensation is applied to any measurement of the strain gauge signal; 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.

5 Supported SDI-12 Commands

Following commands are supported by the TBSSG1:

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 pressure/weight	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aM1!	Additional Measurement Measures PT1000 temperature	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aM2!	Additional Measurement Measures pressure/weight + PT1000 temperature	attt1<CR><LF> Delay (ttt) in seconds and number of values (2)
aM3!	Additional Measurement Measures on chip temperature of the controller	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC!	Start Measurement and request CRC Measures pressure/weight and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC1!	Additional Measurement and request CRC Measures PT1000 temperature and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aMC2!	Additional Measurement and request CRC Measures pressure/weight + PT1000 temperature and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (2)
aMC3!	Additional Measurement and request CRC Measures on chip temperature of the controller and calculates CRC	attt1<CR><LF> Delay (ttt) in seconds and number of values (1)
aC!	Start Concurrent Measurement Measures pressure/weight	attt01<CR><LF> Delay (ttt) in seconds and number of values (1)
aC1!	Start Concurrent Measurement Measures PT1000 temperature	attt01<CR><LF> Delay (ttt) in seconds and number of values (1)
aC2!	Start Concurrent Measurement Measures pressure/weight + PT1000 temperature	attt02<CR><LF> Delay (ttt) in seconds and number of values (2)
aC3!	Start Concurrent Measurement Measures on chip temperature of the controller	attt01<CR><LF> Delay (ttt) in seconds and number of values (1)

aCC!	Start Concurrent Measurement and request CRC Measures pressure/weight and calculates CRC	attt01<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC1!	Start Concurrent Measurement and request CRC Measures PT1000 temperature and calculates CRC	attt01<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC2!	Start Concurrent Measurement and request CRC Measures pressure/weight + PT1000 temperature and calculates CRC	attt02<CR><LF> Delay (ttt) in seconds and number of values (4)
aCC3!	Start Concurrent Measurement and request CRC Measures on chip temperature of the controller and calculates CRC	attt01<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 2 – Standard SDI-12 commands

5.1 Supported Extended Commands

Command	Description	Response
aXSG,g!	Set PGA gain: g = 1 ±4.8V input voltage range for maximum resolution(default setting) g = 2 ±2.4V input voltage range for maximum resolution g = 4 ±1.2V input voltage range for maximum resolution g = 8 ±0.6V input voltage range for maximum resolution g = 16 ±192mV input voltage range for maximum resolution g = 32 ±96mV input voltage range for maximum resolution g = 64 ±48mV input voltage range for maximum resolution g = 128 ±24mV input voltage range for maximum resolution	aX_OK<CR><LF>
aXGG!	Query PGA gain g: gain	a,g<CR><LF>
aXSW,t!	Set the warm up time T: warm up time [ms] (default setting:200ms)	aX_ok<CR><LF>
aXGW!	Query the warm up time t: warm up time [ms]	at<CR><LF>
aXSSP,sa,sb,sc,sd!	Set the coefficients of the scaling-polynomial a, b, c, d: scaling coefficients; s = sign; no sign means positive scaling polynomial: $y = a*x^3 + b*x^2 + c*x + d$	aX_ok<CR><LF>

	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	
aXGSP!	Query the coefficients of the scaling-polynomial	a+a.aaaa+b.bbbb+c.cccc+d.dddd<CR><LF>
aXSTP,sa,sb,sc,sd!	Set the coefficients of the temperature- compensation polynomial 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>
aXGTP!	Query the coefficients of the temperature- compensation polynomial	a+a.aaaa+b.bbbb+c.cccc+d.dddd<CR><LF>
aXSTS,a!	Set the temperature sensor which is to be used for temperature compensation u = sensor type i,I = internal sensor p,P = external sensor (default setting)	aX_ok<CR><LF>
aXGTS!	Query the temperature sensor which is being used for temperature compensation u = sensor type i,I = internal sensor p,P = external sensor (default setting)	a,u<CR><LF>
aXCPT!	PT1000 interface; 0°C calibration Calibration of the PT1000 frontend; connect a 1K, 0,01%, 5ppm precision resistor to the PT1000 pads and send the 0°C cal command. Factory calibrated (no user calibration required.	aX_ok<CR><LF>
aXTEO,saa.aa,u!	Set temperature offset (PT1000 offset compensation) u = unit in which the offset is entered: c,C = Celsius (default setting) f,F = Fahrenheit	aX_OK<CR><LF>
aXSTUu!	Set temperature unit u = F for [°C], u = f for [°F]	aX_OK<CR><LF>
aXGTU!	Query temperature unit	a,u<CR><LF>
aXTIO,saa.aa,u!	Temperature calibration of the internal temperature sensor u = unit in which the offset is entered: c,C = Celsius (default setting) f,F = Fahrenheit	aX_OK<CR><LF>
aXSPUuuu!	Set pressure unit uuu = Pa for [Pascal], uuu = hPa for [hPascal], uuu =k for [kPascal], uuu = bar [bar], uuu = ftH2O for [**Feet Of Water**](default setting)	aX_OK<CR><LF>
aXGPU!	Query pressure unit uuu = Pa for [Pascal], uuu = hPa for [hPascal], uuu =k for [kPascal], uuu = bar [bar] uuu = ftH2O for [**Feet Of Water**](default setting)	a,uuu_OK<CR><LF>
aXSPNnn!	Set number of samples for gliding average Max value nn = 20 [a] is the sensor address Application: gliding averaging; default value is “0”	aX_OK<CR><LF>
aXGPN!	Query number of samples for gliding average	a,nn <CR><LF>

Table 3 – Extended SDI-12 Commands

6 Technical Specifications

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Is	Supply current	Active mode (during measurement)	6mA		10mA	mA
Is	Supply current	Sleep mode		30		µA
Vs	Supply voltage		7		38	V
tm	Measurement Time	Time in active mode upon receiving a measurement command • If the configured warm up time plus sampling time exceeds one second, the response time of the sensor will be increased accordingly		1		s
Vr1	Voltage measurement range	PGA Gain =1		±4.8		V
Vr2	Voltage measurement range	PGA Gain =2		±2.4		V
Vr4	Voltage measurement range	PGA Gain =4		±1.2		V
Vr8	Voltage measurement range	PGA Gain =8		±0.6		V
Vr16	Voltage measurement range	PGA Gain =16		±192		mV
Vr32	Voltage measurement range	PGA Gain =32		±96		mV
Vr64	Voltage measurement range	PGA Gain =64		±48		mV
Vr128	Voltage measurement range	PGA Gain =128		±24		mV
R	Voltage measurement resolution			24		Bit
ENOB	Effective noise free resolution	Dependent on PGA setting	17		20	Bit
LNR	Line noise rejection (50/60Hz)			80		dB
Vbr	5V bridge supply voltage accuracy	not dominating the accuracy due to ratiometric measurement configuration		±50 200		mV ppm/°C
TR_int	Internal sensor: Temperature measurement range		-40		+85	°C
TA_int	Internal sensor: Temperature calibration accuracy	@ 25°C		±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	Differential strain gauge input		15		MOhm
OV_V	Supply input overvoltage protection	Transzorber diode, spark gap,			30	V
TR	Ambient temperature range		-40		+85	°C

Table 4 – Technical Specifications

7 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, no condensation	-	100	%

Table 5 - Environmental Specifications

8 Ordering Information

Part Number	Description
TBSSG1	TBSSG1, PCBA

Table 6 – Ordering Information

9 History

Version	Date	Author	Changes
V1.0	29.01.2014	Mayerhofer	Creation of the document

Table 7 – History