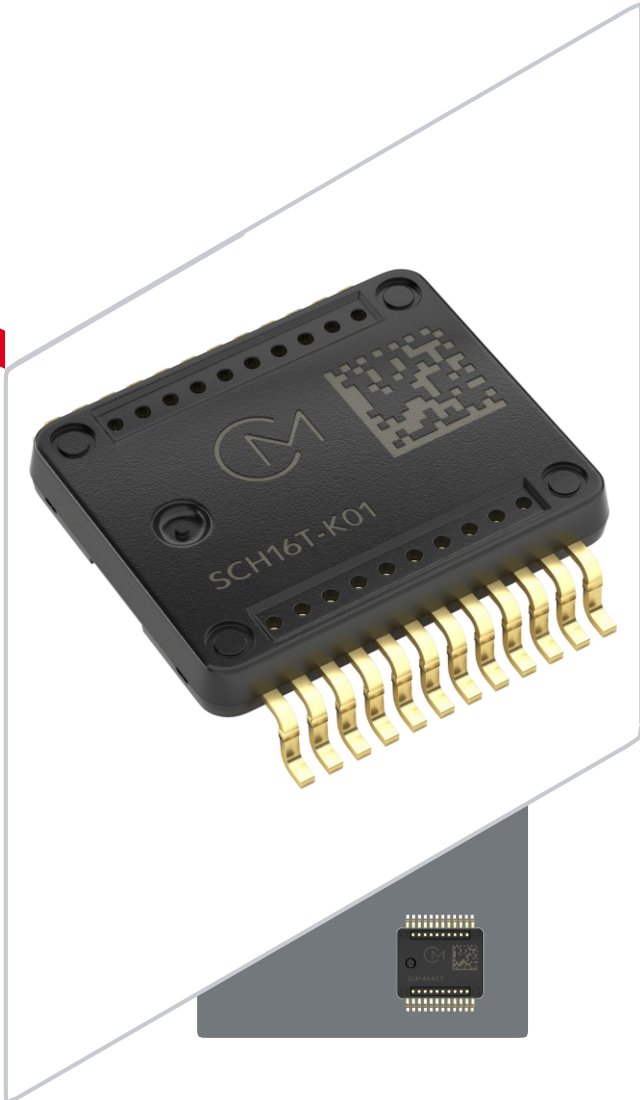
SCH16T-K01 Data Sheet

6-DOF Gyroscope and Accelerometer with Digital SPI Interface



Features

- Gyroscope measurement range selectable in-application from ±300 °/s down to ±62.5 °/s
- Accelerometer measurement range selectable in-application from ±80 m/s² down to ±15 m/s² with default dynamic range of ±260 m/s²
- Options for output interpolation and decimation
- Angular rate and acceleration low pass filters from 13 Hz to 370 Hz cut-off rate
- Data Ready output, timestamp index and SYNC input functions for clock domain synchronization
- -40...110 °C operating temperature range
- 3.0...3.6 V supply voltage, 1.7…3.6 V I/O supply voltage
- SafeSPI v2.0 interface
- 20-bit and 16-bit output data, selectable via SPI frame
- Extensive self-diagnostic features utilizing over 200 monitoring signals
- 11.8 mm x 13.4 mm x 2.9 mm (l x w x h) SOIC-24
- Qualification based on AEC-Q100 standard

Applications

SCH16T-K01 is targeted at applications demanding high performance with tough environmental requirements. Typical applications include:

- Inertial measurement units (IMUs)
- Inertial navigation and positioning
- Machine control and guidance
- Dynamic inclination
- Robotic control and UAVs

Application restriction

- https://www.murata.com/en-global/support/militaryrestriction

Overview

The SCH16T-K01 is a combined high-performance 3-axis angular rate and 3-axis accelerometer. The angular rate and accelerometer sensor elements are based on Murata's proven capacitive 3D-MEMS technology. Signal processing is done by a single mixed-signal ASIC that provides angular rate and acceleration via a flexible SafeSPI v2.0 compliant digital interface. Sensor elements and ASIC are packaged to pre-molded SOIC 24-pin plastic housing that guarantees reliable operation over the product's lifetime.

The SCH16T-K01 is designed, manufactured, and tested for high stability, reliability, and quality requirements. The component has extremely stable output over temperature, humidity, and vibration. The component has several advanced self-diagnostic features, is suitable for SMD mounting and is compatible with RoHS and ELV directives.

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1 Introduction

This document contains essential technical information about the SCH16T series sensor including specifications, SPI interface descriptions, user-accessible register details, electrical properties, and application information. This document should be used as a reference when designing in the SCH16T series sensor.

2 Product and packing quantity information

Table 1 Murata offers products in different packing sizes and types

Product series	Part number	Description	Part number with packing mark	Packing type	Quantity
SCH16T	SCH16T-K01	6-DOF Gyroscope and Accelerometer with Digital SPI Interface, Gyroscope ±300 °/s, Accelerometer ±80 m/s²	SCH16T-K01-PCB	Sample package, Bulk	1 pc
			SCH16T-K01-004		4 pcs
			SCH16T-K01-1	Tape & Reel	100 pcs
			SCH16T-K01-10	Tape & Reel	1000 pcs

3 Specifications

3.1 Abbreviations

ACC	Accelerometer
ARS	Angular Rate Sensor (gyroscope)
ASIC	Application Specific Integrated Circuit
AEC-Q100	Automotive Electronics Council Failure Mechanism Based Stress Test Qualification For Integrated Circuits
CS	Chip Select
DOF	Degrees of Freedom
DPS	Degrees per Second
DRY	Data Ready
F_PRIM	Gyroscope Primary Frequency
FIFO	First In First Out
FREQ	Frequency
Gyro	Gyroscope
LPM	Low Power Mode
LPF	Low-Pass Filter
MCLK	Master Clock
MCU	Microcontroller Unit
MEMS	Micro-Electro-Mechanical System
MISO	Master In Slave Out
MOSI	Master Out Slave In
MSL3	Moisture Sensitivity Level 3 (Moisture and reflow preconditioning)
ODR	Output Data Rate
PD	Pull Down
PU	Pull Up
RT	Room Temperature 25 °C
SCK	Serial Clock
SPI	Serial Peripheral Interface
SYNC	Synchronization

3.2 General specifications

Table 2 General specifications

Parameter	Min	Nom	Max	Unit
Operating temperature (1	-40		110	°C
Supply voltage	3.0	3.3	3.6	V
Digital I/O supply (2	1.7		3.6	V
Total supply current	36	41	47	mA
Low power mode current consumption			10	mA
Gyro primary frequency, F_PRIM	22.1	23.6	25.1	kHz
Output update rate (ODR) - Interpolated outputs (F_PRIM X 16)	353.6	377.6	401.6	kHz
Output update rate (ODR) - Decimated outputs		23.6/X (3		kHz
Component master clock, MCLK		1024 x F_PRIM		kHz
Turn on time (4			250	ms
Weight		0.612		gram

1) Specifications are valid within the temperature range
2) Can exceed supply voltage
3) Decimation ratio X is selectable from the following options: 2, 4, 8, 16 and 32
4) After voltage supplies are within specification

3.3 Absolute maximum ratings

Murata guarantees sensor operation without parameter related damage or functional deviation within these maximum ratings. However, output values are specified only for conditions specified in the chapters *Gyroscope performance specifications* and *Accelerometer performance specifications.* All voltages are related to the potential at GND.

Table 3 Absolute maximum ratings

Parameter	Remark	Min	Nom	Max	Unit
Supply voltage	Supply voltage (pins V3P3, VDDIO)	-0.3		3.63	V
Storage temperature	No damage to the component will occur up to max 24 hours within these maximum ratings	-50		150	°C
Mechanical shock	t ≤ 0.5 ms, XYZ Axis. Tested according to AEC-Q100 requirements.	3000			g
Drop test	Drop to concrete surface, tested according to AEC-Q100 requirements.	1.2			m
ESD_HBM	ESD according to Human Body Model (HBM), Q100-002	2000			V
ESD_CDM center pins	Center pins ESD according to Charged Device Model (CDM), Q100-011	500			V
ESD_CDM corner pins	corner pins ESD according to Charged Device Model (CDM), Q100-011	750			V
Ultrasonic agitation	Cleaning, welding, etc.		Prohibited		

3.4 Gyroscope performance specifications

Table 4 Performance specifications are valid for all measurement axes, up to ±300 °/s measurement range on all outputs, supply voltage = 3.3 V and at 25 °C unless otherwise specified

Parameter	Condition	Min (-3 σ)	Typical	Max (+3 σ)	Unit
Dynamic range A)	Guaranteed output range, default sensitivity		±327.68		°/s
Offset B)	-40 °C ... +110 °C	-0.3	±0.1	0.3	°/s
	-40 °C ... +110 °C, drift over temperature			0.2	
Offset drift over lifetime C)	After HTOL 1000 h	-0.05		0.05	°/s
Offset drift velocity D)	-40 °C ... +85 °C, 0.5 K/min	-0.01		0.01	(°/s)/min
	-40 °C ... +85 °C, 5 K/min	-0.05		0.05	
Default sensitivity E)	Nominal value, 16-bit mode		100		LSB/(°/s)
	Nominal value, 20-bit mode		1600		
Sensitivity error F)	-40 °C ... +110 °C	-0.25	±0.05	0.25	%
	-40 °C ... +110 °C, drift over temperature			0.2	
Sensitivity error drift over lifetime G)	After HTOL 1000 h	-0.2		0.2	%
Linearity error H)	±300 °/s, -40 °C ... +110 °C	-0.3	±0.15	0.3	°/s
	±100 °/s, -40 °C ... +110 °C	-0.04	±0.01	0.04	
Noise density	XY axis		0.0004		(°/s)/√Hz
	Z axis		0.0006		
Angle random walk I)	XY axis		0.015		°/√h
	Z axis		0.025		
Bias instability J)	Allan deviation minimum divided by 0.664		0.3	0.5	°/h
Cross-axis sensitivity K)	-40 °C ... +110 °C, orthogonality error between rate axes	-0.15		0.15	%
	-40 °C ... +110 °C, absolute to package reference	-1		1	
G-sensitivity L)	For constant gravity input	-0.00075		0.00075	(°/s)/g

Notes:

- Specified Min/Max values contain ±3 sigma variation limits of original test population. Typical values are validation population mean (unless otherwise specified). Min/Max and typical values are not guaranteed, values represent validation population characteristics.
- Specification is valid after 24 hours from reflow.
- Each system design including SCH16T series component must be evaluated by the customer in advance to guarantee proper functionality during operation.

Table 5 Gyroscope parameter definitions

Symbol	Description
A)	Measurement range is the rotation speed range where the performance specifications are valid. Dynamic range is the sensor output range where the output is not saturated. Output saturation is indicated by saturation flags documented in chapter *7.3.4 Saturation status summary.* Dynamic and measurement ranges are affected by user configurable sensitivity settings.
B)	Offset is the sensor output deviation from zero at zero rate and acceleration. Offset over temperature is determined over one temperature sweep in the specified temperature range. $\text{Offset drift over temperature} = \frac{\text{maximum offset value over temperature} - \text{minimum offset value over temperature}}{2}$
C)	Offset drift over lifetime is estimated from offset drift from initial offset before MSL3 treatment to offset after 1000 hours of high temperature operating life (HTOL) test at 125 °C and maximum supply voltages.
D)	Offset drift velocity is the change rate of the zero-rate offset for predefined temperature gradients within a specified temperature range.
E)	Default sensitivity used in factory calibration. Sensitivity is affected by user configurable sensitivity settings defined in chapter *7.4.2 Dynamic range and decimation* $\text{Sensitivity} = \frac{\text{AR}_{\text{meas}}(\Omega_{\text{max}}) - \text{AR}_{\text{meas}}(\Omega_{\text{min}})}{\Omega_{\text{max}} - \Omega_{\text{min}}}$ Where: Ω_{max} = applied angular rate at 100 °/s Ω_{min} = applied angular rate at -100 °/s $AR_{meas}(\Omega_n)$ = measured angular rate at Ω_n [LSB] Sensor outputs data in 2's complement format.
F)	$\text{Sensitivity error} = \frac{\text{Sensitivity} - \text{nominal sensitivity}}{\text{nominal sensitivity}} \times 100\ \%$ Sensitivity error over temperature is determined over one temperature sweep in specified temperature range. $\text{Sensitivity error drift over temperature} = \frac{\text{maximum sensitivity error value over temperature} - \text{minimum sensitivity error value over temperature}}{2}$
G)	Sensitivity error drift over lifetime is estimated from sensitivity drift during 1000 hours of high temperature operating life (HTOL) test at 125 °C and maximum supply voltages. Drift in percentage points.
H)	Linearity error is the maximum deviation from the best fit straight line defined by the measured values at the specified range end points. Best fit linear model uses a least-squares linear fit.
I)	Angle random walk is the white noise term estimated from Allan deviation at tau = 1 s.
J)	Bias instability is the Allan deviation minimum divided by 0.664. Measured with 13 Hz low pass filter setting, 200 Hz sample rate and fifteen-minute stabilization time before data collection starts to permit full thermal stabilization.
K)	Cross-axis sensitivity is the sensitivity on axes other than the intended axis of rotation. $\text{Cross} - \text{axis sensitivity} = \frac{\text{AR}_{\text{meas}}}{\Omega_{other}} \times 100\ \%$ Where: Ω_{other} = applied angular rate along an axis other than the measured axis AR_{meas}= the measured angular rate Murata calibrates gyroscope and accelerometer axes at component calibration line and therefore orthogonality error is the residual cross-axis error after system level orientation against fixed acceleration (gravity).
L)	Angular rate offset sensitivity in respect to orientation in the earth gravitation. This value is only measured from orientations that are not affected by the earth's rotation (0.004 °/s) and therefore, is not verified in all orientations. Can not be extrapolated beyond gravitation.

3.5 Accelerometer performance specifications

Table 6 Performance specifications are valid for all measurement axes, up to ±80 m/s² measurement range on all outputs (default and auxiliary), supply voltage = 3.3 V and at 25 °C unless otherwise specified

Parameter	Condition	Min (-3 σ)	Typical	Max (+3 σ)	Unit
Dynamic range A)	Guaranteed output range, default output, default sensitivity		±163.84		m/s²
	Auxiliary accelerometer output, default sensitivity	±260			
Offset B)	-40 °C ... +110 °C	-0.06	±0.02	0.06	m/s²
	-40 °C ... +110 °C, drift over temperature			0.04	
Offset drift over lifetime C)	After HTOL 1000 h	-0.02		0.02	m/s²
Offset drift velocity D)	-40 °C ... +110 °C, 0.5 K/min	-0.002		0.002	(m/s²)/min
	-40 °C ... +110 °C, 5 K/min	-0.005		0.005	
Default sensitivity E)	Nominal value, 16-bit mode		200		LSB/(m/s²)
	Nominal value, 20-bit mode		3200		
Default sensitivity for auxiliary accelerometer output E)	Nominal value, 16-bit mode		100		LSB/(m/s²)
	Nominal value, 20-bit mode		1600		
Sensitivity error F)	-40 °C ... +110 °C	-0.1	±0.05	0.1	%
	-40 °C ... +110 °C, drift over temperature			0.05	
Sensitivity error drift over lifetime G)	After HTOL 1000 h	-0.03		0.03	%
Linearity error H)	±80 m/s², -40 °C ... +110 °C	-0.15	±0.03	0.15	m/s²
	±10 m/s², -40 °C ... +110 °C	-0.01	±0.005	0.01	
Noise density			0.8		(mm/s²)/$\sqrt{Hz}$
Velocity random walk I)			30		(mm/s)/$\sqrt{h}$
Bias instability J)	Allan deviation minimum divided by 0.664		0.15	0.3	mm/s²
Cross-axis sensitivity K)	-40 °C ... +110 °C, orthogonality error between ACC axes	-0.15		0.15	%
	-40 °C ... +110 °C, absolute to package reference	-1		1	

Notes:

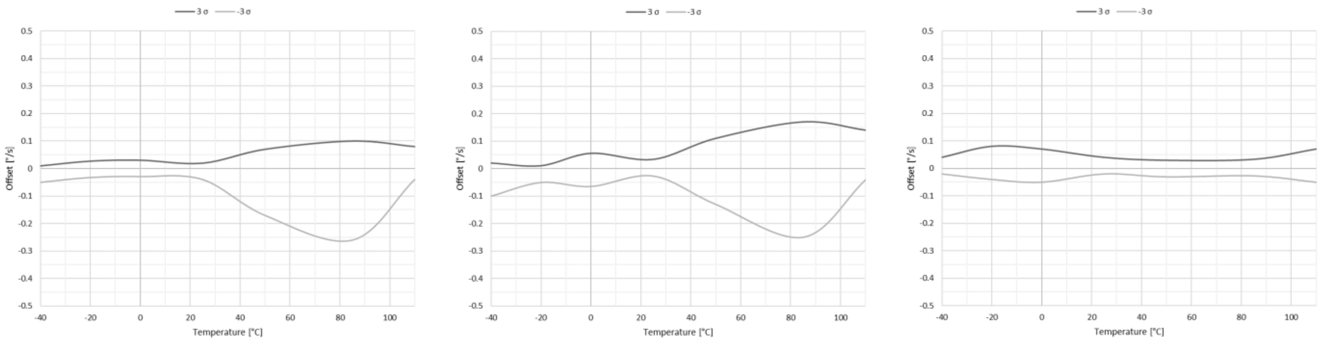
- Specified Min/Max values contain ±3 sigma variation limits of original test population. Typical values are validation population mean (unless otherwise specified). Min/Max and typical values are not guaranteed, values represent validation population characteristics.
- Specification is valid after 24 hours from reflow.
- Each system design including SCH16T series component must be evaluated by the customer in advance to guarantee proper functionality during operation.
- A factor of 102 can be used when converting m/s² to milli-g. Actual gravity depends on sensor location on Earth.

Table 7 Accelerometer parameter definitions

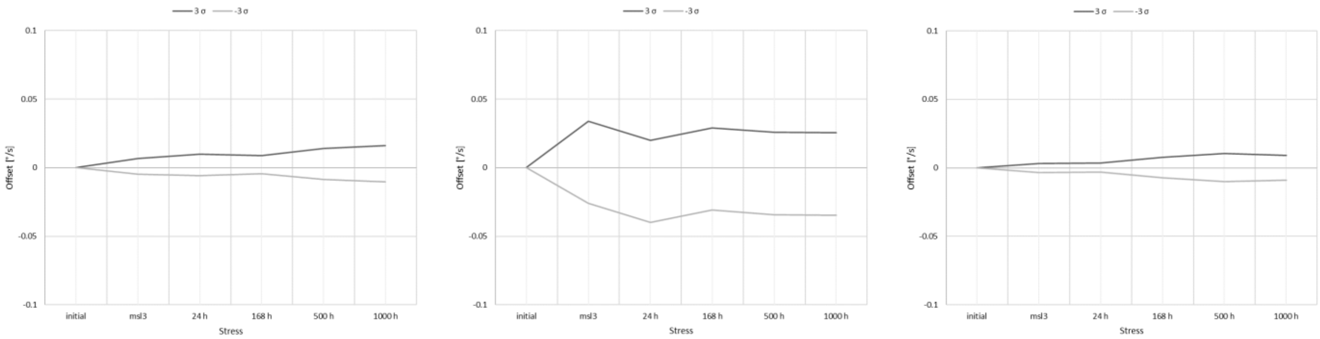
Symbol	Description
A)	Measurement range is the acceleration range where the performance specifications are valid. Dynamic range is the sensor output range where the output is not saturated. Output saturation is indicated by saturation flags documented in chapter *7.3.4 Saturation status summary.* Dynamic and measurement ranges are affected by user configurable sensitivity settings.
B)	Offset is the sensor output deviation from zero at zero rate and acceleration. Offset over temperature is determined over one temperature sweep in the specified temperature range. $\text{Offset drift over temperature} = \frac{\text{maximum offset value over temperature} - \text{minimum offset value over temperature}}{2}$
C)	Offset drift over lifetime is estimated from offset drift from initial offset before MSL3 treatment to offset after 1000 hours of high temperature operating life (HTOL) test at 125 °C and maximum supply voltages.
D)	Offset drift velocity is the change rate of the zero-acceleration offset for predefined temperature gradients within a specified temperature range.
E)	Default sensitivity used in factory calibration. Sensitivity is affected by user configurable sensitivity settings defined in chapter *7.4.2 Dynamic range and decimation* $\text{Sensitivity} = \frac{\text{ACC}_{\text{meas}}(a_{+1g}) - \text{ACC}_{\text{meas}}(a_{-1g})}{a_{+1g} - a_{-1g}}$ a_{+1g} = applied acceleration at +1 g (i.e., +1 g gravity of manufacturing location) a_{-1g} = applied acceleration at -1 g (i.e., -1 g gravity of manufacturing location) $ACC_{meas}(a_n)$ = measured acceleration at a_n [LSB] Sensor outputs data in 2's complement format.
F)	$\text{Sensitivity error} = \frac{\text{Sensitivity} - \text{nominal sensitivity}}{\text{nominal sensitivity}} \times 100\ \%$ Sensitivity error over temperature is determined over one temperature sweep in specified temperature range. $\text{Sensitivity error drift over temperature} = \frac{\text{maximum sensitivity error value over temperature} - \text{minimum sensitivity error value over temperature}}{2}$
G)	Sensitivity error drift over lifetime is estimated from sensitivity drift during 1000 hours of high temperature operating life (HTOL) test at 125 °C and maximum supply voltages. Drift in percentage points.
H)	Linearity error is the maximum deviation from the best fit straight line defined by the measured values at the specified range end points. Best fit linear model uses a least-squares linear fit.
I)	Velocity random walk is the white noise term estimated from Allan deviation at tau = 1 s.
J)	Bias instability is the Allan deviation minimum divided by 0.664. Measured with 13 Hz low pass filter setting, 200 Hz sample rate and fifteen-minute stabilization time before data collection starts to permit full thermal stabilization.
K)	Cross-axis sensitivity is the sensitivity on axes other than the intended axis of acceleration. $\text{Cross} - \text{axis sensitivity} = \frac{\text{ACC}_{\text{meas}}}{a_{other}} \times 100\ \%$ Where: a_{other} = applied acceleration along an axis other than the measured axis ACC_{meas}= the measured acceleration Murata calibrates gyroscope and accelerometer axes at component calibration line and therefore orthogonality error is the residual cross-axis error after system level orientation against fixed acceleration (gravity).

3.6 Gyroscope typical performance characteristics

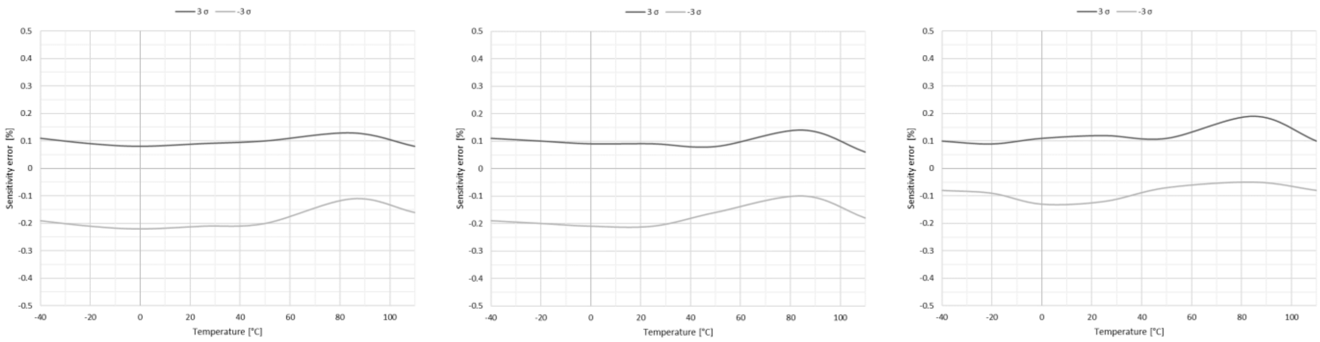
X-Axis	Y-Axis	Z-Axis



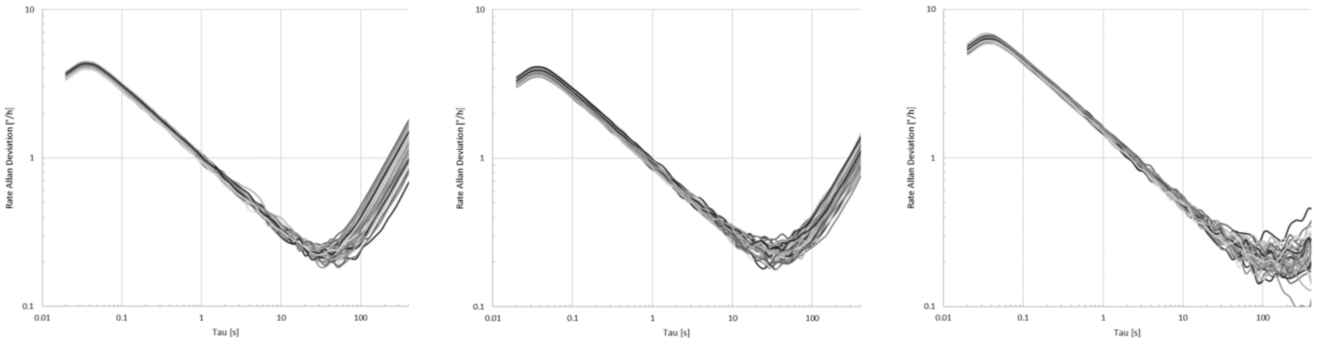
Offset (°/s) 3 σ population limits



Offset drift over lifetime (HTOL 1000 h) (°/s) 3 σ population limits (25 °C)



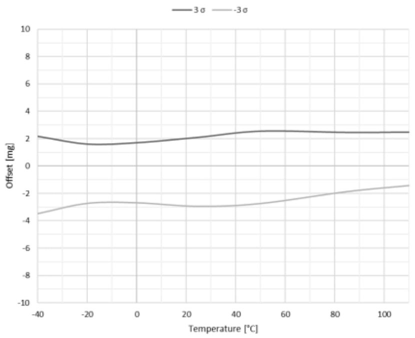
Sensitivity error (%) 3 σ population limits

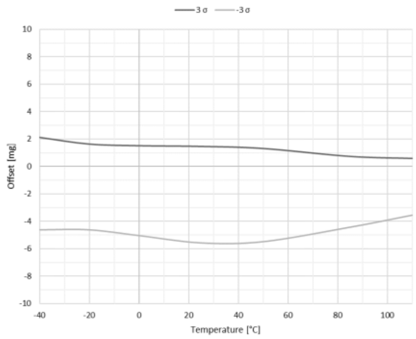


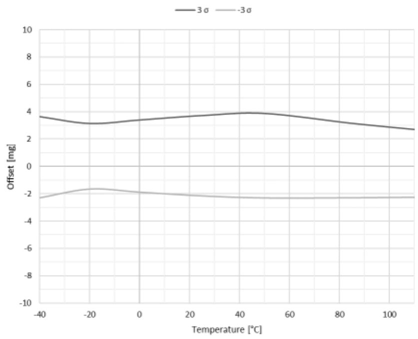
Allan Deviation (°/h)

3.7 Accelerometer typical performance characteristics

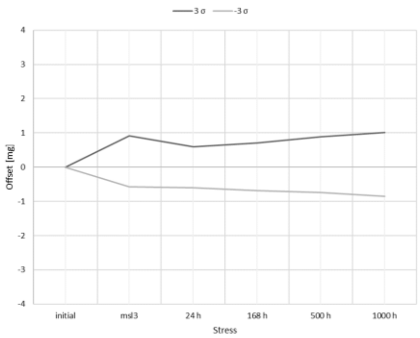
X-Axis	Y-Axis	Z-Axis

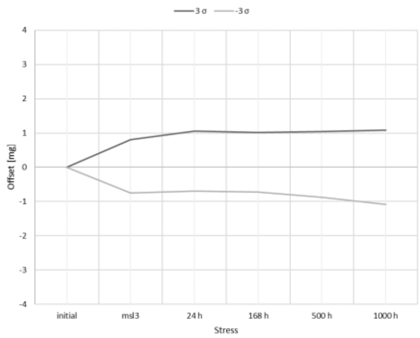


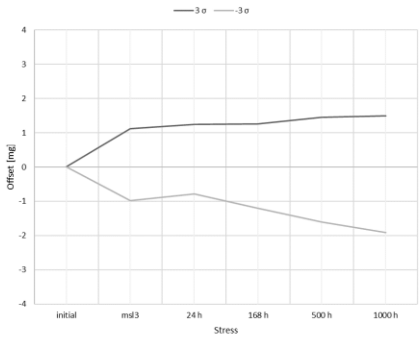




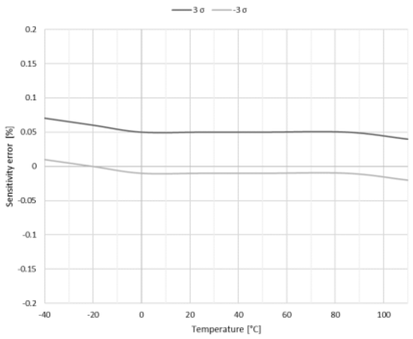
Offset (mg) 3 σ population limits

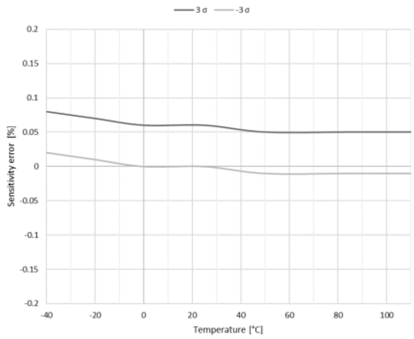


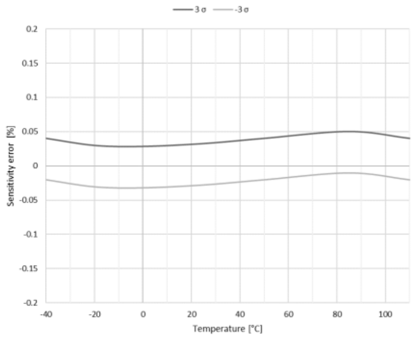




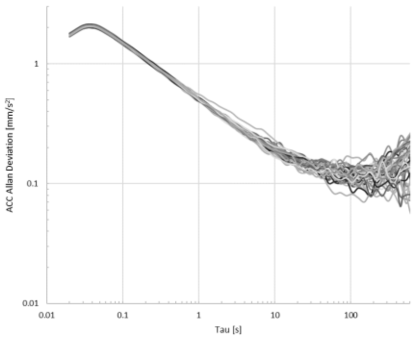
Offset drift over lifetime (HTOL 1000 h) (mg) 3 σ population limits

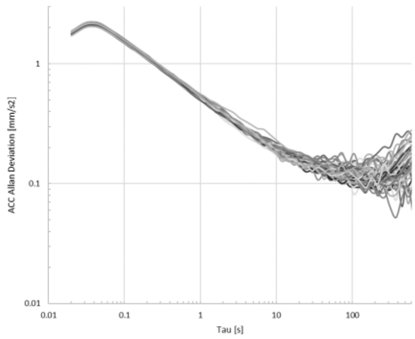


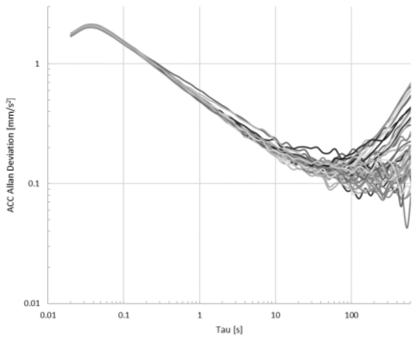




Sensitivity error (%) 3 σ population limits







Allan Deviation (mm/s^2)

3.8 Temperature sensor performance specifications

Table 8 Temperature sensor performance specification

Parameter	Min	Nom	Max	Unit
Measurement range	-50		135	°C
Temperature signal sensitivity		100		LSB/°C
Total error	-15		15	°C
Linearity	-1		1	°C

Temperature is converted to °C with following equation:

Temperature [°C] = TEMP / 100, where TEMP is temperature sensor output register content in 2's complement format.

3.9 Gyroscope and accelerometer frequency response and filter characteristics

Table 9 SCH16T-K01 component low pass filter characteristics. Empty columns are not defined.

Filter	Axis	Title	Type	Order	Min	Nom	Max	Unit
LPF0	Gyroscope	Cut-off frequency (-3 dB)	Butterworth	4	63.5	68	72.5	Hz
		Group Delay					10	ms
		Settling time				10	20	ms
	Accelerometer	Cut-off frequency (-3 dB)	Butterworth	4	63.5	68	72.5	Hz
		Group Delay					10	ms
		Settling time						ms
LPF1	Gyroscope	Cut-off Frequency (-3 dB)	Butterworth	4	28	30	32	Hz
		Group Delay					22	ms
		Settling time				25	40	ms
	Accelerometer	Cut-off Frequency (-3 dB)	Butterworth	4	28	30	32	Hz
		Group Delay					16	ms
		Settling time						ms
LPF2	Gyroscope	Cut-off Frequency (-3 dB)	Butterworth	3	12.2	13	13.8	Hz
		Group Delay					35	ms
		Settling time				65	200	ms
	Accelerometer	Cut-off Frequency (-3 dB)	Butterworth	3	12.2	13	13.8	Hz
		Group Delay					35	ms
		Settling time						ms
LPF3	Gyroscope	Cut-off Frequency (-3 dB)	Bessel	4	262	280	300	Hz
		Group Delay					2.5	ms
		Settling time					5	ms
	Accelerometer	Cut-off Frequency (-3 dB)	Bessel	4	200	240	275	Hz
		Group Delay					1.95	ms
		Settling time						ms
LPF4	Gyroscope	Cut-off Frequency (-3 dB)	Bessel	3	346	370	394	Hz
		Group Delay					2	ms
		Settling time						ms
	Accelerometer	Cut-off Frequency (-3 dB)	Bessel	3	234	290	380	Hz
		Group Delay					1.56	ms
		Settling time						ms
LPF5	Gyroscope	Cut-off Frequency (-3 dB)	Bessel	3	220	235	250	Hz
		Group Delay					2.5	ms
		Settling time						ms
	Accelerometer	Cut-off Frequency (-3 dB)	Bessel	3	179	210	235	Hz
		Group Delay					2.05	ms
		Settling time						ms
LPF7	Gyroscope	Cut-off Frequency (-3 dB)				Bypass		Hz
		Group Delay						ms
		Settling time					0.78	ms
	Accelerometer	Cut-off Frequency (-3 dB)				Bypass		Hz
		Group Delay						ms
		Settling time					0.78	ms

Group delay is the derivate of the phase in respect to frequency, measured at 10Hz. Settling time is the time for the signal to settle within ±0.1% of input signal.

3.10 Pin description

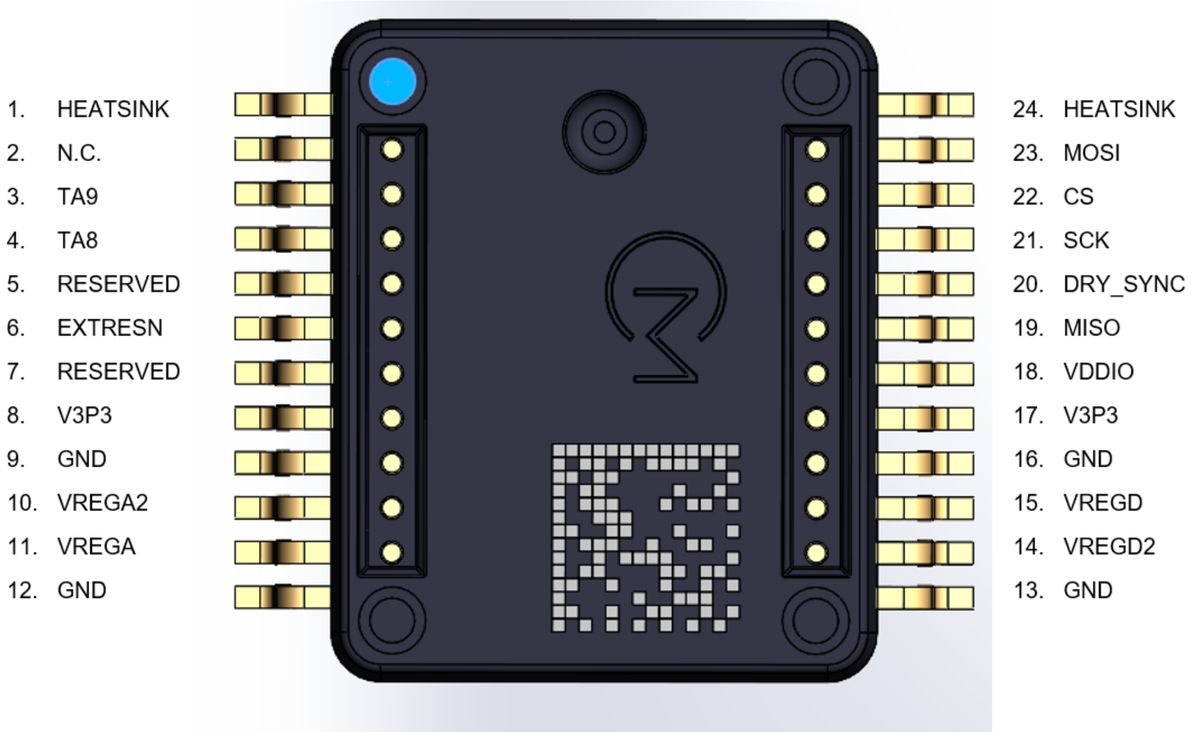


Figure 1 SCH16T series pin layout

Table 10 SCH16T series pin description

Pin #	Name	Description	Type	Voltage level	Default state/structure
1	HEATSINK	Heatsink connection	GND	0 V	
2	Reserved	Leave floating	N/A		
3	TA9	SPI device selection Address 1 (static). Slave addressing in SafeSPI2. Max four slaves can be addresses by TA9:8. TA on the slave is defined by VDDIO logic level at pins TA9 and TA8. Connect to ground for default '0' address.	DIN	0 V	0/PDR[1)]
4	TA8	SPI device selection Address 0 (static). Slave addressing in SafeSPI2. Max four slaves can be addresses by TA9:8. TA on the slave is defined by VDDIO logic level at pins TA9 and TA8. Connect to ground for default '0' address.	DIN	0 V	0/PDR[1)]
5	Reserved	Connect to GND	N/A		
6	EXTRESN	External reset input (low active) during normal operation.	DIN/AIN	VDDIO	1/PUR[1)]
7	Reserved	Connect to GND	N/A		
8	V3P3	External unregulated inputs for the core supply regulators	SUPPLY	3.3 V	
9	GND	Ground	GND	0 V	

Pin #	Name	Description	Type	Voltage level	Default state/structure
10	VREGA2	Regulated core voltage for the analog circuitry. External capacitor connection for positive reference/supply voltage. Connected in PCB.	AIN	2.5 V	
11	VREGA	Regulated core voltage for the analog circuitry. External capacitor connection for positive reference/supply voltage. Connected in PCB.	AOUT	2.5 V	
12	GND	Ground	GND	0 V	
13	GND	Ground	GND	0 V	
14	VREGD2	Regulated core voltage for the digital circuitry. External capacitor connection for positive reference/supply voltage. Connected in PCB.	AIN	1.5 V	
15	VREGD	Regulated core voltage for the digital circuitry. External capacitor connection for positive reference/supply voltage. Connected in PCB.	AOUT	1.5 V	
16	GND	Ground	GND	0 V	
17	V3P3	External unregulated inputs for the core supply regulators	SUPPLY	3.3 V	
18	VDDIO	Digital supply IO	SUPPLY	3.3 V (option: 1.8 V or 2.5 V)	
19	MISO	Master In Slave Out (SPI)	DOUT	VDDIO	TRI
20	DRY_SYNC	SYNC input (active high) DRY (Data Ready) outputs an interrupt signal when the internal output registers (decimated gyroscope and accelerometer) have been updated until the first decimated register is read.	DIN/DOUT	VDDIO	0/PDR
21	SCK	Serial Clock (SPI)	DIN	VDDIO	0/PDR
22	CS	Chip Select (SPI)	DIN	VDDIO	1/PUR
23	MOSI	Master Out Slave In (SPI)	DIN	VDDIO	0/PDR
24	HEATSINK	Heatsink connection	GND	0 V	

1) Strong PD/PU resistance during device supply POR reset state, otherwise weak PD/PU.

3.11 Digital I/O specification

Table 11 SPI DC characteristics describes DC characteristics of the SCH16T series SPI I/O pins. Current flowing into the circuit has a positive value.

Table 11 SPI DC characteristics.

Title	Symbol	Min	Max	Unit
SPI voltage level	VIO	1.7	3.6	V
Input high voltage	VIH	0.7*VIO	VIO	V
Input low voltage	VIL	0	0.3*VIO	V
Input voltage hysteresis	VHYST	0.05*VIO		V
Input/output capacitance	CIO		10	pF
Total MISO load capacitance [1], <Wide> range	CLWIDE	10	100	pF
Input pull-down resistance, strong (default)	RPD	60	140	kOhm
Input pull-up resistance, strong (default)	RPU	60	140	kOhm
Input pull-down/pull-up resistance, weak (option)	RPD/RPU	200	400	kOhm
Output leakage current in case MISO is in high impedance (tri-state) condition	ILEAK	-10	10	µA

1) For maximum supported MISO capacitance see SPI AC specifications

3.12 SPI AC characteristics

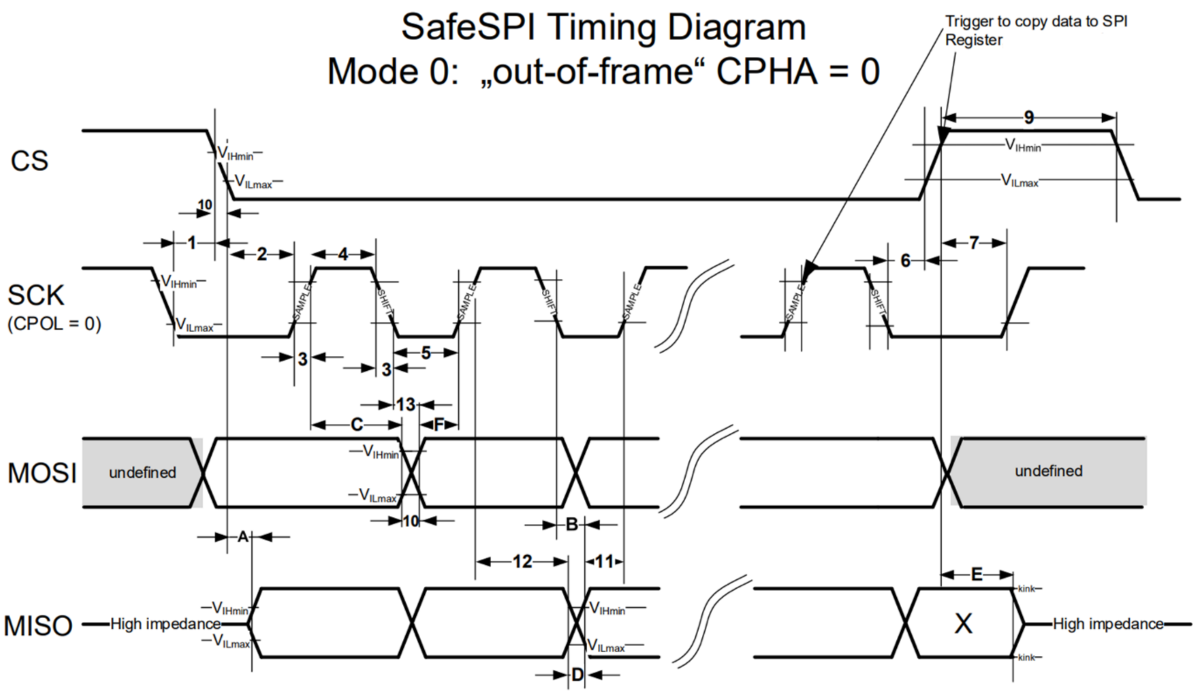


Figure 2 Timing diagram of SPI communication (SPI mode 0), CPOL = 0, CPHA = 0

Table 12 SPI AC electrical characteristics. Default mode is MISO_HI_SPD = 0. If MISO_HI_SPD = 1 setting is used it must be set up first after startup.

Title	Remark	Symbol	MISO_HI_SPD = 0 (Default)		MISO_HI_SPD = 1		Unit
			Min	Max	Min	Max	
SCK operating frequency			0.095	10.5	0.095	25.5	MHz
MISO data valid time (CS)	Time delay from the falling edge of CS to data valid at MISO	A		40		17	ns
MISO data valid time (SCK)	Time delay from the falling edge of SCK to data valid at MISO	B		32		14	ns
MOSI data hold time	Hold time of MOSI after rising edge of SCK	C	20		8		ns
MISO rise and fall time	MISO rise and fall time is not defined during transition between high impedance and active mode (MISO load max 200 pF)	D	2	10	NA	NA	ns
MISO rise and fall time	MISO rise and fall time is not defined during transition between high impedance and active mode (MISO load max 100 pF)	D	2	9	0.3	5	ns
MISO rise and fall time	MISO rise and fall time is not defined during transition between high impedance and active mode (MISO load max 50 pF)	D	2	9	0.3	4	ns
MISO data disable lag time	Time between the rising edge of CS to MISO in Tri-state	E		50		21	ns
MOSI data setup time	Setup time of MOSI before the rising edge of SCK	F	10		4		ns
SCK disable lead time	Time between the falling edge of SCK and the falling edge of CS	1	10		10		ns
SCK enable lead time	Time between the falling edge of CS and the rising edge of SCK	2	40		17		ns
SCK rise and fall time	Rise and fall time of SCK signals	3	2	9	0	3.5	
SCK high time	Duration of logical high level at SCK	4	37		16		ns
SCK low time	Duration of logical low level at SCK	5	37		16		ns
SCK enable lag time	Time between the falling edge of SCK and the rising edge of CS	6	20		8		ns
SCK disable lag time	Time between the rising edge of CS and the rising edge of SCK	7	10		10		ns
Sequential transfer delay	In case of MOSI write commands (RW=1)	9	750		450		ns
Sequential transfer delay	In case of MOSI read commands (RW=0)	9	450		450		ns
MOSI rise and fall time	Rise and fall time of MOSI signals	10	2	9	0	3.5	ns
MISO data setup time	Setup time of MISO before the rising edge of SCK	11	5		2		ns
MISO data hold time	Hold time of MISO after rising edge of SCK	12	X[1)]		X[1)]		ns
MOSI valid time	Valid time of MOSI after the falling edge of SCK	13		10		4	ns
CS rise and fall time	Rise and fall time of CS signals	10	2	9	0	3.5	ns

1) MISO data is guaranteed to be stable until the next SCK shift edge

3.13 Measurement axis and directions

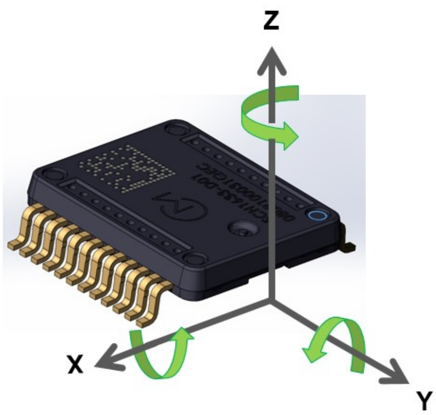


Figure 3 SCH16T series measurement directions for gyroscope and accelerometer. Output is showing positive value when component is moved in the direction of the arrow.

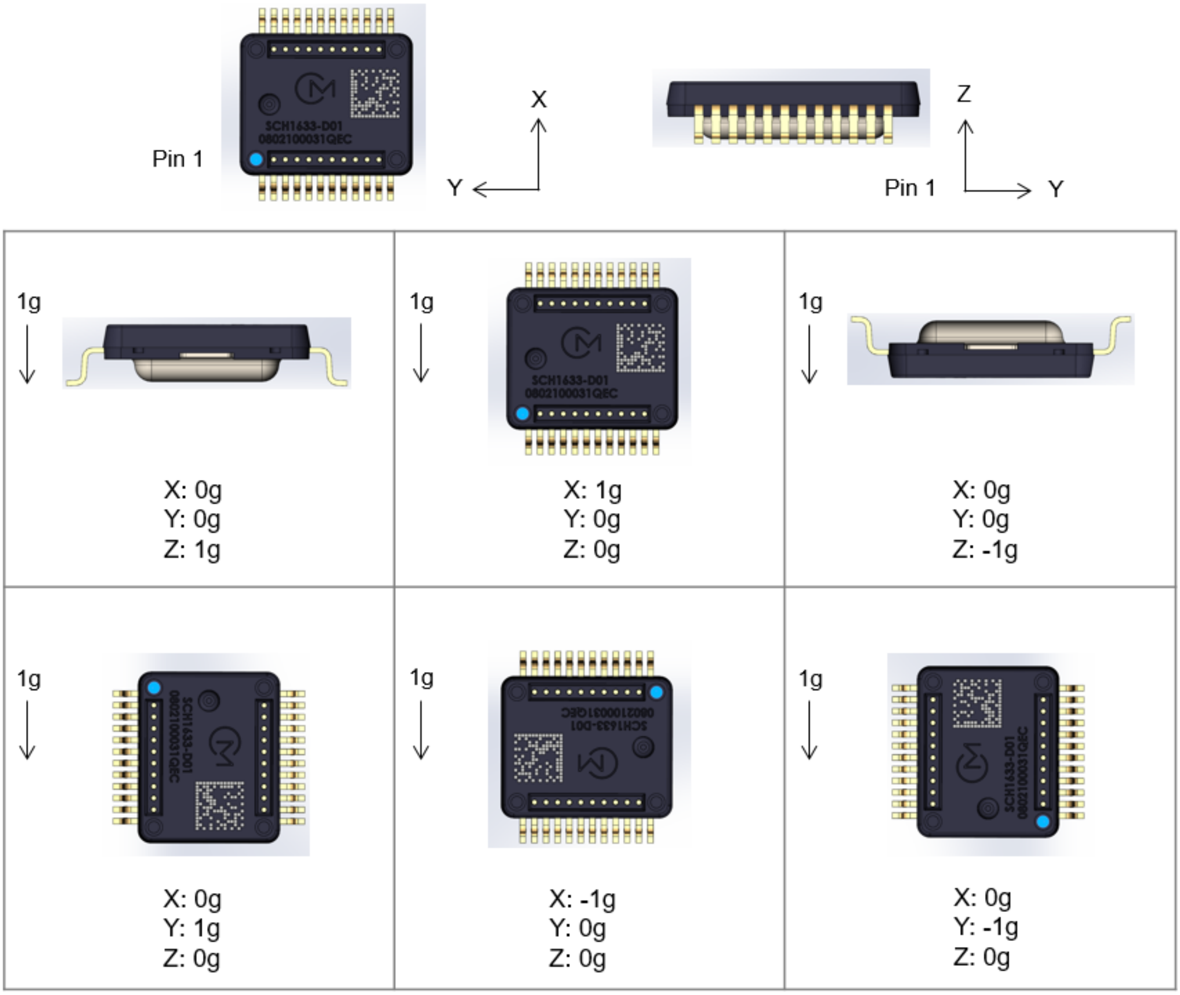


Figure 4 SCH16T series accelerometer measurement directions and outputs. 1 g indicates direction of gravity. Note: Pin 1 is marked in blue only in this data sheet to emphasize location.

3.14 Package outline and dimensions

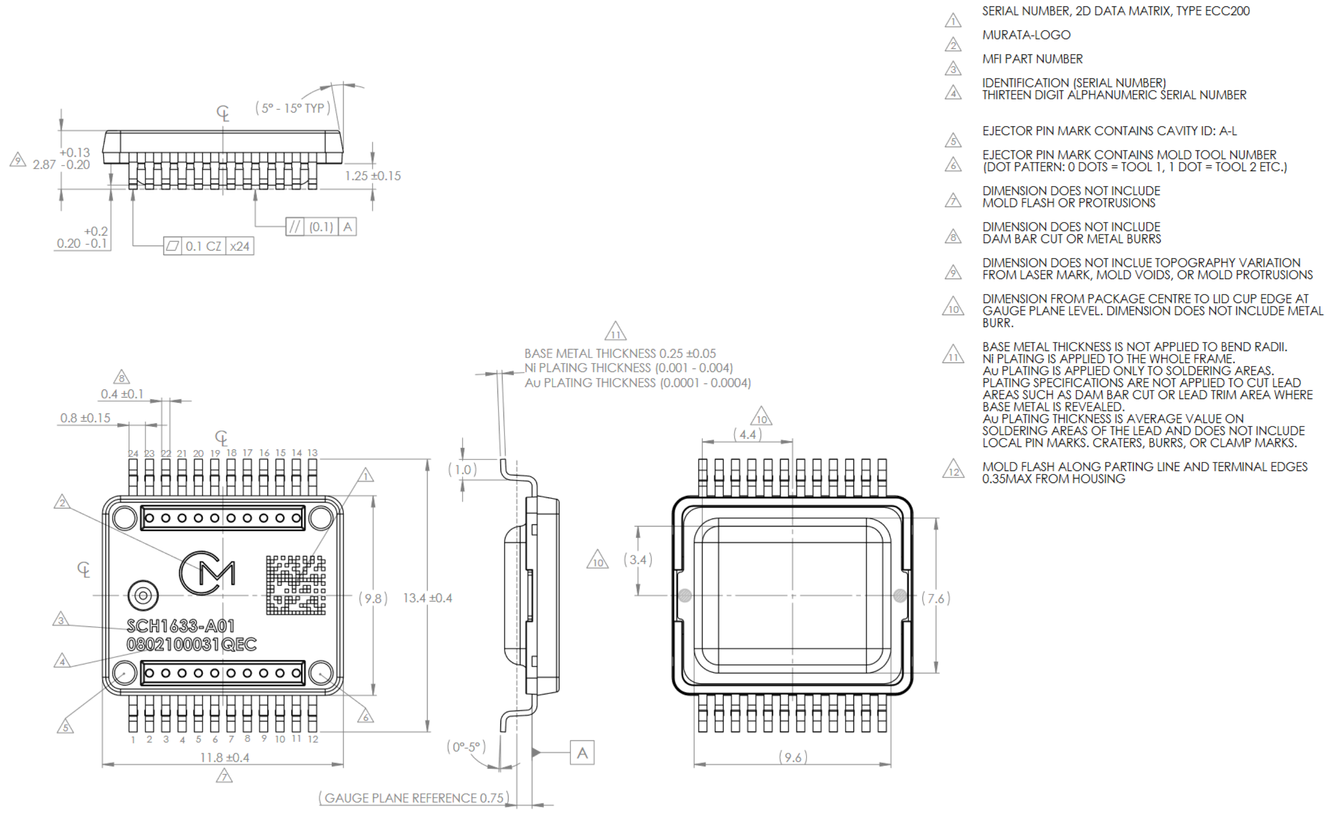


Figure 5 Outline of SOIC package. All dimensions are in millimeters. All angles are in degrees. Tolerances unless otherwise specified according to ISO2768-f. A sample part number for reference only.

3.15 PCB footprint

SCH16T series PCB footprint dimensions are presented in the figure below.

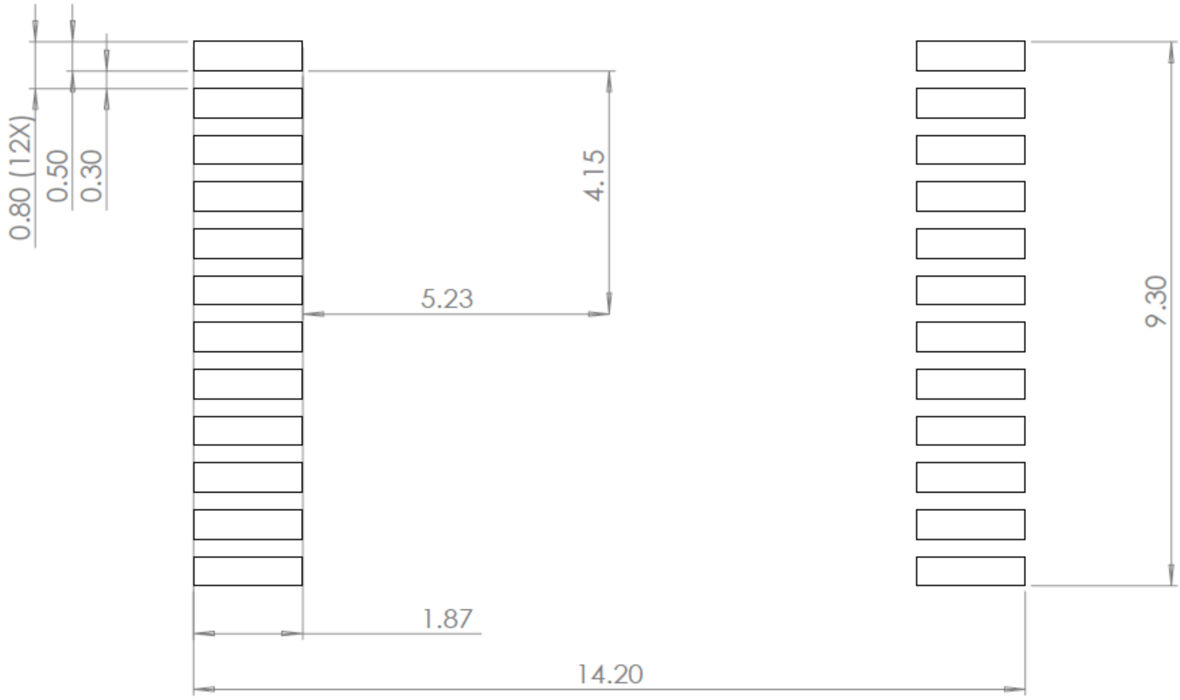


Figure 6 Recommended PCB pad layout for SCH16T series. All dimensions are in millimeters.

This is the end of the short data sheet. For full version of the data sheet and an assembly instructions document, please contact Murata.