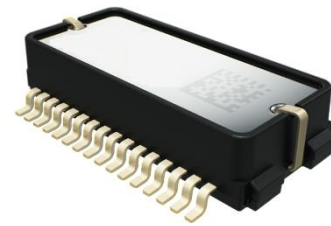




# THE DATASHEET OF SCHA63T-K03-05



# SCHA63T-K03 Data Sheet



## SCHA63T-K03: 6-DOF XYZ-Axis Gyroscope and xyz-Axis Accelerometer with digital SPI interface

### Features

- $\pm 300^\circ/\text{s}$  angular rate measurement range
- $\pm 6 \text{ g}$  acceleration measurement range
- $-40^\circ\text{C} \dots +110^\circ\text{C}$  operating temperature range
- 3.0V...3.6V supply voltage
- 2 SPI digital interfaces
- Extensive self-diagnostics features
- Size 19.71 mm x 12.15 mm x 4.6 mm (l x w x h), 32 pins
- RoHS compliant robust SOIC plastic package suitable for lead free soldering process and SMD mounting
- Proven capacitive 3D-MEMS technology
- Can be used in Safety Critical Applications

### Applications

SCHA63T-K03 is targeted at applications demanding high performance with tough environmental requirements. Typical applications include:

- Inertial Measurement Units (IMUs)
- Navigation and positioning
- Machine control and guidance
- Dynamic inclination
- Robotic control and UAVs

### Restriction

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

## Overview

The SCHA63T-K03 is a combined high performance 3-axis angular rate and 3-axis accelerometer. It consists of X-, Y- and Z-axis angular rate sensors and integrated 3-axis accelerometer based on Murata's proven capacitive 3D-MEMS technology. Signal processing is done with two mixed signal ASICs that provides angular rate via flexible SPI digital interface. Sensor elements and ASIC are packaged to premolded SOIC 32 plastic housing that guarantees reliable operation over product's lifetime.

The SCHA63T-K03 is designed, manufactured and tested for high stability, reliability and quality requirements. Component has extremely stable output over temperature, humidity and vibration. Component has several advanced self-diagnostic features and 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 SCHA63T-K03 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 SCHA63T-K03 component.

## **2 Specifications**

### **2.1 Abbreviations**

|        |   |
|--------|---|
| ASIC   | Application Specific Integrated Circuit         |
| CCM    | Channel calibration and monitoring              |
| Cpk    | Process Capability Index                        |
| CSB    | Chip Select                                     |
| CST    | Continuous Self Test                            |
| DPS    | Degrees per second                              |
| DUE    | ASIC for ZY-axis rate                           |
| FFB    | Force Feedback (Gyro operating principle)       |
| FS     | Full scale                                      |
| HPC    | High Performance Combo                          |
| MOSI   | Master Out Slave In                             |
| MISO   | Master In Slave Out                             |
| MCU    | Microcontroller                                 |
| RT     | Room Temperature                                |
| SCK    | Serial Clock                                    |
| SPI    | Serial Peripheral Interface                     |
| UNO    | ASIC for X-axis rate and XYZ-axis accelerometer |
| F_prim | Gyro primary frequency                          |
| Rx     | Rate X axis                                     |
| Ry     | Rate Y axis                                     |
| Rz     | Rate Z axis                                     |
| Ax     | Accelerometer X axis                            |
| Ay     | Accelerometer Y axis                            |
| Az     | Accelerometer Z axis                            |

## 2.2 General Specifications

General specifications for SCHA63T-K03 component are presented in Table 1. All analog voltages are related to the potential at GNDA and all digital voltages are related to the potential at GNDD.

**Table 1. General specifications.**

| Parameter                         | Condition   | sc/cc | Min | Typ          | Max | Unit |
|-----------------------------------|---|-------|-----|--------------|-----|------|
| Supply voltage: V3p3A             |   |       | 3.0 | 3.3          | 3.6 | V    |
| Supply voltage: V3p3D             |   |       | 3.0 | 3.3          | 3.6 | V    |
| Supply current: V3p3A<br>DUE      |   |       |     | 8.5          |     | mA   |
| Supply current: V3p3D<br>DUE      |   |       |     | 9.5          |     | mA   |
| Supply current: V3p3A+D<br>DUE    |   |       |     | 18           |     | mA   |
| Supply current: V3p3A<br>UNO      |   |       |     | 6.25         |     | mA   |
| Supply current: V3p3D<br>UNO      |   |       |     | 6.25         |     | mA   |
| Supply current: V3p3A+D<br>UNO    |   |       |     | 12.5         |     | mA   |
| Total current, I_TOTAL<br>UNO+DUE | I_V3p3A + I_V3p3D<br>Temperature range -40 ... +110 °C  | CC    |     | 30.5         |     | mA   |
| Total current reset<br>UNO+DUE    | Total average current during reset  |       |     |              | 4   | mA   |
| Output update rate                | Gyro, Accelerometer and Temperature<br>sensor   |       |     | F_prim<br>/2 |     | Hz   |
| TMODE                             | Wait time to set the operation mode after<br>the supply in the specification.<br>Wait time needed after power on or after<br>reset. (Wait time starts when supply is<br>inside spec limits.) SPI is not functional<br>during this time. |       | 25  |              |     | ms   |
| TSPIR                             | SPI communication is not allowed for 2ms<br>after SPI Hardreset.  |       | 2   |              |     | ms   |

## 2.3 Performance Specifications for Gyroscope

Table 2. Gyro performance specifications (VDD = 3.3 V and at room temperature unless otherwise specified). Below values are from device Product and Process Validation (PV) phase unless otherwise specified.

| Parameter  | Condition   | Axis | Min    | Typ      | Max    | Unit    |
|--|---|------|--------|----------|--------|---------|
| Measurement range                                | Minimum saturation flag   | XYZ  | ± 300  |          |        | °/s     |
| Offset <sup>A)</sup>                             | Offset after calibration, 3 $\sigma$<br>N > 234   | XYZ  | -0.8   | 0        | 0.8    | °/s     |
| Offset temperature dependency <sup>B)</sup>      | -40°C ≤ T ≤ +110°C, 3 $\sigma$<br>N = 234   | XY   | -0.65  |          | 0.65   | °/s     |
|  |   | Z    | -0.085 |          | 0.085  | °/s     |
| Offset change over lifetime <sup>C)</sup>        | 1000 hours of high temperature operating life (HTOL) at 125°C, VDD=3.6V<br>N = 234  | XY   | -0.22  |          | 0.22   | °/s     |
|  |   | Z    | -0.06  |          | 0.06   | °/s     |
| Sensitivity <sup>D)</sup>                        | Sensitivity after calibration at ±300°/s, 3 $\sigma$<br>N > 90  | XYZ  | 79     | 80       | 81     | LSB/°/s |
| Sensitivity temperature dependency <sup>E)</sup> | -40°C ≤ T ≤ +110°C, 3 $\sigma$<br>N = 234   | XY   | -0.2   |          | 0.6    | %       |
|  |   | Z    | 0      |          | 0.2    | %       |
| Sensitivity change over lifetime <sup>F)</sup>   | 1000 hours of high temperature operating life (HTOL) at 125°C, VDD=3.6V<br>N = 234  | XY   | -0.75  |          | 0.75   | %       |
|  |   | Z    | -0.21  |          | 0.21   | %       |
| Linearity error <sup>G)</sup>                    | End point fit to ±300 °/s<br>N = 12   | XYZ  |        | 0.15     | 0.25   | °/s     |
| Noise density                                    | 3 $\sigma$ , N = 12   | XYZ  |        | 0.0015   | 0.0019 | °/s/√Hz |
| Angle Random Walk                                | 3 $\sigma$ , N = 12   | XYZ  |        | 0.09     | 0.11   | °/√h    |
| Bias Instability <sup>H) I) J)</sup>             | At RT, Allan Variance minimum divided by 0.664, 3 $\sigma$ , N = 12   | XYZ  |        | 1.64     | 2.57   | °/h     |
| Orthogonality error                              | Axis to axis after external cross axis compensation, 3 $\sigma$ , N = 234   | XYZ  | -0.25  |          | 0.25   | %       |
| Amplitude response -3 dB frequency               | 13 Hz Filter, 3 $\sigma$ , N = 15   | XYZ  | 12.1   | 13.6     | 14.3   | Hz      |
|  | 20 Hz Filter, 3 $\sigma$ , N = 15   |      | 18.5   | 20.2     | 21.5   | Hz      |
|  | 46 Hz Filter, 3 $\sigma$ , N = 15   |      | 42.1   | 46.1     | 48.9   | Hz      |
|  | 300 Hz Filter, 3 $\sigma$ , N = 15  |      | 280    | 305.8    | 325.6  | Hz      |
| Power on start-up time <sup>k)</sup>             | 13 Hz filter (after SPI power on command), MAX  | XYZ  |        |          | 620    | ms      |
|  | 20 Hz filter (after SPI power on command), MAX  |      |        |          | 620    | ms      |
|  | 46 Hz filter (after SPI power on command), MAX  |      |        |          | 500    | ms      |
|  | 300 Hz filter (after SPI power on command), MAX   |      |        |          | 500    | ms      |
| F_prim   | Nominal operation frequency of the sensor element. All ASIC internal clocks are derived from a multiple of this frequency | XY   | 15.8   | 16.8     | 17.8   | kHz     |
|  |   | Z    | 18.3   | 19.3     | 20.3   | kHz     |
| Output update rate                               |   | XYZ  |        | F_prim/2 |        |         |
| G sensitivity(1g x,y,z axis static)              | For DC gravity input, 3 $\sigma$ , N = 48   | XYZ  |        |          | 0.006  | (°/s)/g |

- A) Initial offset at Murata Production measurement after calibration
- B) Offset temperature dependency is determined by the larger absolute value of [(maximum offset over temperature) – (offset at 25°C)] or [(minimum offset over temperature) – (offset at 25°C)]
- C) Estimated from offset change during 1000 hours of high temperature operating live (HTOL) test at 125°C and maximum supply voltages
- D) Sensitivity is defined as

$$Sensitivity = \frac{AR_{meas}(\Omega_{max}) - AR_{meas}(\Omega_{min})}{\Omega_{max} - \Omega_{min}}$$

Where

$\Omega_{max}$ =applied angular rate at maximum operating range

$\Omega_{min}$ =applied angular rate at minimum operating range

$AR_{meas}(\Omega_n)$ =measured angular rate at  $\Omega_n$  [LSB]

- E) Sensitivity temperature dependency is determined by the larger absolute value of [(maximum sensitivity value over temperature) - (sensitivity at 25°C)] /sensitivity at 25°C\*100% or [(minimum sensitivity value over temperature) - (sensitivity at 25°C)] /sensitivity at 25°C\*100%
- F) Estimated from sensitivity change during 1000 hours of high temperature operating life (HTOL) test at 125°C and maximum supply voltages
- G) Linearity is the maximum deviation from the straight line defined by the measured values at the operating range end points.
- H) Allan Variance Minimum divided by 0.664

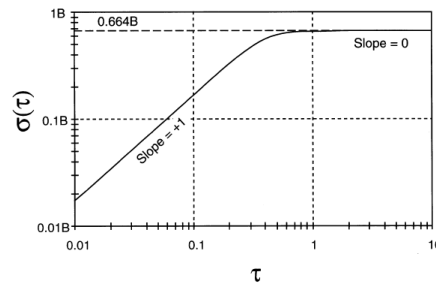


Figure C.2— $\sigma(\tau)$  Plot for bias instability (for  $f_0 = 1$ )

- I) Optimization for SPI duty cycle or sample rate is required to achieve typical Allan variance in table
- J) Device powered four hours before data collection starts to permit fully settling from power up.
- K) Max values are determined from product platform validations

Note :

- Specification is valid after 24hours from reflow.
- Each system design including SCHA63T-K03 must be evaluated by the customer in advance to guarantee proper functionality during operation.
- Min and Max values are from validation mean  $\pm 3$  sigma variation limits from test population at the minimum. Min and Max values are not guaranteed. Nominal values are mean values from validation test population.

## 2.4 Performance Specifications for Accelerometer

Table 3. Accelerometer performance specifications (VDD = 3.3 V and room temperature unless otherwise specified). Below values are from device Product and Process Validation (PV) phase unless otherwise specified.

| Parameter  | Condition   | Axis | Min   | Typ   | Max   | Unit                           |
|--|---|------|-------|-------|-------|--------------------------------|
| Measurement range                                | Minimum saturation flag   | XYZ  | 6     |       |       | g                              |
| Offset <sup>A)</sup>                             | Offset after calibration, 3 $\sigma$<br>N = 234                                       | XYZ  | -13.5 |       | 13.5  | mg                             |
| Offset temperature dependency <sup>B)</sup>      | -40°C ≤ T ≤ +110°C, 3 $\sigma$<br>N = 234   | XYZ  | -7.3  |       | 7.3   | mg                             |
| Offset change over lifetime <sup>C)</sup>        | 1000 hours of high temperature operating life (HTOL) at 125°C,<br>VDD=3.6V<br>N = 234 | XYZ  | -22   |       | 22    | mg                             |
| Sensitivity <sup>D)</sup>                        | Sensitivity after calibration at ±1g, 3 $\sigma$<br>N = 234                           | XYZ  | 4899  | 4905  | 4911  | LSB/g                          |
| Sensitivity temperature dependency <sup>E)</sup> | -40°C ≤ T ≤ +110°C, 3 $\sigma$<br>N = 234   | XYZ  | -0.15 |       | 0.15  | %                              |
| Sensitivity change over lifetime <sup>F)</sup>   | 1000 hours of high temperature operating life (HTOL) at 125°C,<br>VDD=3.6V<br>N = 234 | XYZ  | -0.06 |       | 0.06  | %                              |
| Linearity error <sup>G)</sup>                    | End point fit to ±6g<br>3 $\sigma$ , N = 30   | XYZ  | 1.9   | 6.3   | 17.2  | mg                             |
|  | End point fit to ±1g<br>3 $\sigma$ , N = 30   | XYZ  |       |       | 1     | mg                             |
| Noise density                                    | 3 $\sigma$ , N = 12   | XYZ  |       | 59.5  | 66.0  | $\mu\text{g}/\sqrt{\text{Hz}}$ |
| Velocity random walk                             | 3 $\sigma$ , N = 12   | XYZ  |       | 35.0  | 38.8  | $\text{mm/s}/\sqrt{\text{h}}$  |
| Bias instability                                 | At RT, Allan Variance minimum divided by 0.664, 3 $\sigma$ , N = 12                   | XYZ  |       | 12.2  | 18.3  | $\mu\text{g}$                  |
| Orthogonality error                              | Axis to axis after external cross axis compensation, 3 $\sigma$ , N = 234             | XYZ  | -0.14 |       | 0.14  | %                              |
| Amplitude response -3 dB frequency               | 13 Hz Filter, 3 $\sigma$ , N = 15   | XYZ  | 13.2  | 13.7  | 14.2  | Hz                             |
|  | 20 Hz Filter, 3 $\sigma$ , N = 15   | XYZ  | 19.7  | 20.3  | 20.8  | Hz                             |
|  | 46 Hz Filter, 3 $\sigma$ , N = 15   | XYZ  | 45.0  | 46.3  | 47.5  | Hz                             |
|  | 300 Hz Filter, 3 $\sigma$ , N = 15  | XYZ  | 247.4 | 264.2 | 286.7 | Hz                             |
| Power on start-up time <sup>H)</sup>             | 13 Hz filter (after SPI power on command), MAX  | XYZ  |       |       | 450   | ms                             |
|  | 20 Hz filter (after SPI power on command), MAX  |      |       |       | 450   | ms                             |
|  | 46 Hz filter (after SPI power on command), MAX  |      |       |       | 320   | ms                             |
|  | 300 Hz filter (after SPI power on command), MAX                                       |      |       |       | 320   | ms                             |
| Output update rate                               | Tied to X-gyro F <sub>prim</sub> /2   | XYZ  | 7.9   | 8.4   | 8.9   | kHz                            |

- A) Initial offset at Murata Production measurement after calibration
- B) Offset temperature dependency is determined by the larger absolute value of [(maximum offset over temperature) – (offset at 25°C)] or [(minimum offset over temperature) – (offset at 25°C)]
- C) Estimated from offset change during 1000 hours of high temperature operating life (HTOL) test at 125°C
- D) Sensitivity is defined as

$$Sensitivity = \frac{ACC_{meas}(a_{+1g}) - ACC_{meas}(a_{-1g})}{a_{+1g} - a_{-1g}}$$

Where

a<sub>+1g</sub>=applied acceleration at +1g

a<sub>-1g</sub>=applied acceleration at -1g

ACC<sub>meas</sub>(a<sub>n</sub>)=measured acceleration at a<sub>n</sub> [LSB]

- E) Sensitivity temperature dependency is determined by the larger absolute value of [(maximum sensitivity value over temperature) - (sensitivity at 25°C)] /sensitivity at 25°C\*100% or [(minimum sensitivity value over temperature) - (sensitivity at 25°C)] /sensitivity at 25°C\*100%
- F) Estimated from Sensitivity change during 1000 hours of high temperature operating life (HTOL) test at 125°C
- G) Linearity is the maximum deviation from the straight line defined by the measured values at the specified range end points.
- H) Max values are determined from product platform validations

Note :

- Specification is valid after 24hours from reflow.
- Each system design including SCHA63T-K03 must be evaluated by the customer in advance to guarantee proper functionality during operation.
- Min and Max values are validation ±3 sigma variation limits from test population at the minimum. Min and Max values are not guaranteed. Nominal values are mean values from validation test population.

## 2.5 Performance Specification for Temperature Sensor

**Table 4. Temperature sensor performance specifications.**

| Parameter                      | Condition  | Min. | Typ | Max. | Unit   |
|--------------------------------|--|------|-----|------|--------|
| Temperature signal range       |  | -50  |     | +150 | °C     |
| Temperature signal sensitivity | Temperature sensor output in 2's complement format |      | 30  |      | LSB/°C |

Temperature is converted to °C with following equation:

$$\text{Temperature [°C]} = 25 + (\text{TEMP} / 30),$$

where TEMP is temperature sensor output register content in decimal format.

## 2.6 Cross-Axis Compensation

SCHA63T-K03 ASIC stores the cross-axis compensation and offset fine tuning terms both for the rate and accelerometer and cross-axis compensation can be done in the external microprocessor according to the following equations.

### Equation 1: Rate Cross-Axis Compensation

$$\vec{\Omega}_{real} = \begin{pmatrix} c_{xx} & c_{xy} & c_{xz} \\ c_{yx} & c_{yy} & c_{yz} \\ c_{zx} & c_{zy} & c_{zz} \end{pmatrix} * (\vec{\Omega}_{meas} - \vec{\Omega}_{offs})$$

where

$c_{ii}$  = is the corresponding rate cross-axis compensation term (in non-volatile memory, see Table 5: Cross-Axis Compensation Register Map)

### Equation 2: Compensated rate vector

$$\vec{\Omega}_{real} = \begin{pmatrix} \Omega_{rx} \\ \Omega_{ry} \\ \Omega_{rz} \end{pmatrix}$$

### Equation 3: Measured rate vector (from the component)

$$\vec{\Omega}_{meas} = \begin{pmatrix} \Omega_{mx} \\ \Omega_{my} \\ \Omega_{mz} \end{pmatrix}$$

Equation 4: Rate offset compensation vector (Not stored in the memory). Rate offset zeroing in system level e.g. after PCB assembly is recommended.

$$\vec{\Omega}_{offs} = \begin{pmatrix} \Omega_{ox} \\ \Omega_{oy} \\ \Omega_{oz} \end{pmatrix}$$

For the accelerometers following equations apply:

**Equation 5: Accelerometer Cross-Axis Compensation**

$$a_{real}^{\vec{}} = \begin{pmatrix} b_{xx} & b_{xy} & b_{xz} \\ b_{yx} & b_{yy} & b_{yz} \\ b_{zx} & b_{zy} & b_{zz} \end{pmatrix} * (a_{meas}^{\vec{}} - a_{offs}^{\vec{}})$$

where

$b_{ii}$  = is the corresponding accelerometer cross-axis compensation term (see Table 5: Cross-Axis Compensation Register Map)

**Equation 6: Compensated accelerometer vector**

$$a_{real}^{\vec{}} = \begin{pmatrix} a_{rx} \\ a_{ry} \\ a_{rz} \end{pmatrix}$$

**Equation 7: Measured accelerometer vector (from the component)**

$$a_{meas}^{\vec{}} = \begin{pmatrix} a_{mx} \\ a_{my} \\ a_{mz} \end{pmatrix}$$

**Equation 8: Acceleration offset compensation vector (Not stored in the memory). Acceleration offset zeroing in system level e.g. after PCB assembly is recommended.**

$$a_{offs}^{\vec{}} = \begin{pmatrix} a_{ox} \\ a_{oy} \\ a_{oz} \end{pmatrix}$$

*Note: Sensing element axes are independent from each other by the mechanical design. The cross-axis compensation doesn't affect to axis independency as long as no axes are saturated.*

**Table 5: Cross-Axis Compensation Register Map**

| Parameter       | Bank (DUE ASIC) | Address (hex) | Register       | Range (2's complement) | Floating number |
|-----------------|-----------------|---------------|----------------|------------------------|-----------------|
| C <sub>xx</sub> | 05h             | 0Bh           | ACC_DC1[7:0]   | - 128 .. 127 LSB       | 1+value/4096    |
| C <sub>xy</sub> | 05h             | 0Bh           | ACC_DC1[15:8]  | - 128 .. 127 LSB       | value/4096      |
| C <sub>xz</sub> | 05h             | 13h           | ACC_DC9[7:0]   | - 128 .. 127 LSB       | value/4096      |
| C <sub>yx</sub> | 05h             | 13h           | ACC_DC9[15:8]  | - 128 .. 127 LSB       | value/4096      |
| C <sub>yy</sub> | 05h             | 14h           | ACC_DC10[7:0]  | - 128 .. 127 LSB       | 1+value/4096    |
| C <sub>yz</sub> | 05h             | 14h           | ACC_DC10[15:8] | - 128 .. 127 LSB       | value/4096      |
| C <sub>zx</sub> | 05h             | 15h           | ACC_DC11[7:0]  | - 128 .. 127 LSB       | value/4096      |
| C <sub>zy</sub> | 05h             | 15h           | ACC_DC11[15:8] | - 128 .. 127 LSB       | value/4096      |
| C <sub>zz</sub> | 05h             | 16h           | ACC_DC12[7:0]  | - 128 .. 127 LSB       | 1+value/4096    |
| b <sub>xx</sub> | 05h             | 16h           | ACC_DC12[15:8] | - 128 .. 127 LSB       | 1+value/4096    |
| b <sub>xy</sub> | 05h             | 17h           | ACC_DC13[7:0]  | - 128 .. 127 LSB       | value/4096      |
| b <sub>xz</sub> | 05h             | 17h           | ACC_DC13[15:8] | - 128 .. 127 LSB       | value/4096      |
| b <sub>yx</sub> | 05h             | 18h           | ACC_DC14[7:0]  | - 128 .. 127 LSB       | value/4096      |
| b <sub>yy</sub> | 05h             | 18h           | ACC_DC14[15:8] | - 128 .. 127 LSB       | 1+value/4096    |
| b <sub>yz</sub> | 05h             | 1Bh           | ACC_MD1[7:0]   | - 128 .. 127 LSB       | value/4096      |
| b <sub>zx</sub> | 05h             | 1Bh           | ACC_MD1[15:8]  | - 128 .. 127 LSB       | value/4096      |
| b <sub>zy</sub> | 05h             | 1Ch           | ACC_MD2[7:0]   | - 128 .. 127 LSB       | value/4096      |
| b <sub>zz</sub> | 05h             | 1Ch           | ACC_MD2[15:8]  | - 128 .. 127 LSB       | 1+value/4096    |

### 2.6.1 Test Mode For Reading Cross-Axis Terms

Procedure

- 1) Activate test mode (open lock) after Step 3 (or 4 or 5 or 6) of start-up sequence in Figure 7
  - Write/Read Register 19h (Mode)
    - Write Mode='RRRRRRRR RR010RRR'b
    - Read Mode
    - Write Mode='RRRRRRRR RR001RRR'b
    - Read Mode
    - Write Mode='RRRRRRRR RR100RRR'b
    - Read Mode
    - Dummy read, for example read Mode to get Mode read response
  - Verify test mode
    - Check the read data bits Mode[2:0]='111'b
- 2) Change bank to 5
  - Write data 5'h to address 1F'h
- 3) Read cross-axis terms
  - Read registers according to Table 5
- 4) Save cross-axis terms to MCU
- 5) Power-off or SPI reset command via register 18h or reset by EXTRESN pin to exit test mode
- 6) Return to Step 1 of start-up sequence in Figure 7

\*Write operation to an unspecified register after test mode access may permanently damage the component.

### 2.7 Absolute Maximum Ratings

Within the maximum ratings (Table 6. Absolute maximum ratings.), no damage to the component shall occur. Parametric values may deviate from specification, yet no functional deviation shall occur. All analog voltages are related to the potential at GNDA, all digital voltages are related to GNDD.

**Table 6. Absolute maximum ratings.**

| Parameter | Remark   | Min.                       | Typ | Max.             | Unit |
|-----------|--|----------------------------|-----|------------------|------|
| VDD       | Supply voltage                                     | -0.3                       |     | 4.3              | V    |
| AIN/AOUT  | Maximum voltage at analog input and output pins    | -0.3                       |     | VDD+0.3<br>(4.3) | V    |
| DIN/DOUT  | Maximum voltage at digital input and output pins   | -0.3                       |     | VDD+0.3<br>(4.3) | V    |
| Topr      | Operating temperature range                        | -40                        |     | 110              | °C   |
| Tstg      | Storage temperature range                          | -40                        |     | 150              | °C   |
| ESD_HBM   | ESD according Human Body Model (HBM), Q100-002     | ±2000                      |     |                  | V    |
| ESD_MM    | ESD according Machine Model (MM), Q100-003         | ±200                       |     |                  | V    |
| ESD_CDM   | ESD according Charged Device Model (CDM), Q100-011 | ±500<br>±750 (corner pins) |     |                  | V    |
| US        | Ultrasonic agitation (cleaning, welding, etc)      | Prohibited                 |     |                  |      |

## 2.8 Pin Description

The pinout for SCHA63T-K03 is presented in Figure 1, while the pin descriptions can be found in Table 7.

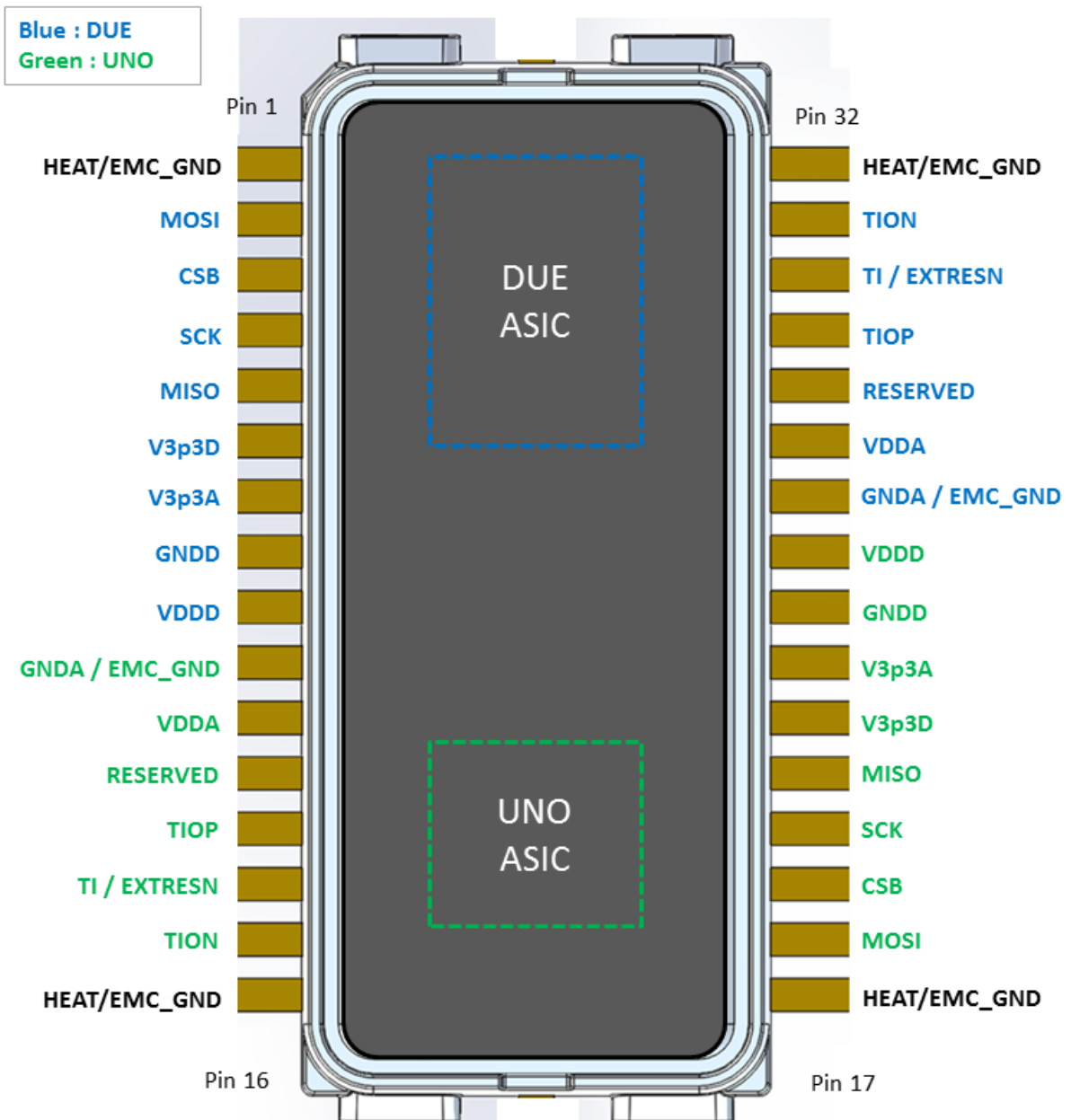


Figure 1. Pinout for SCHA63T-K03.

**Table 7. SCHA63T-K03 pin descriptions.**

| Pin# | Name           | ASIC | Type   | Description  |
|------|----------------|------|--------|--|
| 1    | HEAT/EMC_GND   | -    | GND    | Heatsink interface to GNDA   |
| 2    | MOSI           | DUE  | DIN    | Data In of SPI Interface   |
| 3    | CSB            | DUE  | DIN    | Chip Selected of SPI Interface   |
| 4    | SCK            | DUE  | DIN    | Clock Signal of SPI Interface  |
| 5    | MISO           | DUE  | DOUT   | Data Out of SPI Interface  |
| 6    | V3p3D          | DUE  | SUPPLY | Digital Supply voltage   |
| 7    | V3p3A          | DUE  | SUPPLY | Analog Supply voltage  |
| 8    | GNDD           | DUE  | GND    | Digital Supply return (ground), connect externally to GNDA.  |
| 9    | VDDD           | DUE  | AOUT   | Regulated supply for digital core. Use external capacitor which is connected according to the diagram in Figure 15.  |
| 10   | GNDA / EMC_GND | UNO  | GND    | Analog Supply return (ground), connect externally to GNDD  |
| 11   | VDDA           | UNO  | AOUT   | Regulated supply for analog core. Use external capacitor which is connected according to the diagram in Figure 15.   |
| 12   | RESERVED       | UNO  | -      | Factory use only, connect to GND   |
| 13   | TIOP           | UNO  | -      | Factory use only, connect to GND.  |
| 14   | TI/EXTRESN     | UNO  | DIN    | Optional external Reset, 3.3V logic compatible Schmitt-trigger input with internal pull-up, LOW-HIGH transition causes system restart. Minimum low time 100us. |
| 15   | TION           | UNO  | -      | Factory use only, connect to GND.  |
| 16   | HEAT/EMC_GND   | -    | GND    | Heatsink interface to GNDA   |
| 17   | HEAT/EMC_GND   | -    | GND    | Heatsink interface to GNDA   |
| 18   | MOSI           | UNO  | DIN    | Data In of SPI Interface   |
| 19   | CSB            | UNO  | DIN    | Chip Selected of SPI Interface   |
| 20   | SCK            | UNO  | DIN    | Clock Signal of SPI Interface  |
| 21   | MISO           | UNO  | DOUT   | Data Out of SPI Interface  |
| 22   | V3p3D          | UNO  | SUPPLY | Digital Supply voltage   |
| 23   | V3p3A          | UNO  | SUPPLY | Analog Supply voltage  |
| 24   | GNDD           | UNO  | GND    | Digital Supply return (ground), connect externally to GNDA.  |
| 25   | VDDD           | UNO  | AOUT   | Regulated supply for digital core. Use external capacitor which is connected according to the diagram in Figure 15.  |
| 26   | GNDA / EMC_GND | DUE  | GND    | Analog Supply return (ground), connect externally to GNDD  |
| 27   | VDDA           | DUE  | AOUT   | Regulated supply for analog core. Use external capacitor which is connected according to the diagram in Figure 15.   |
| 28   | RESERVED       | DUE  | -      | Factory use only, connect to GND   |
| 29   | TIOP           | DUE  | -      | Factory use only, connect to GND.  |
| 30   | TI/EXTRESN     | DUE  | DIN    | Optional external Reset, 3.3V logic compatible Schmitt-trigger input with internal pull-up, LOW-HIGH transition causes system restart. Minimum low time 100us. |
| 31   | TION           | DUE  | -      | Factory use only, connect to GND.  |
| 32   | HEAT/EMC_GND   | -    | GND    | EMC protection and ground  |

## 2.9 Typical performance characteristics

## 2.9.1 Gyro typical characteristics

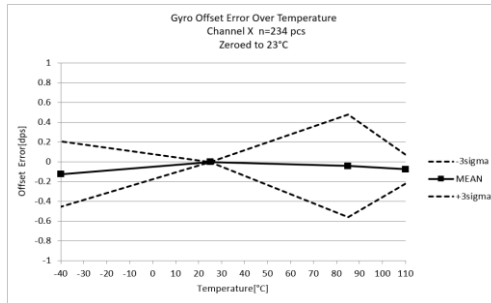


Chart 1 Gyro Offset Error over temperature X-axis

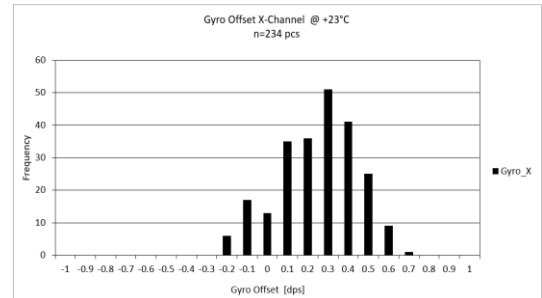


Chart 2 Gyro Offset Error @ +23°C X-axis

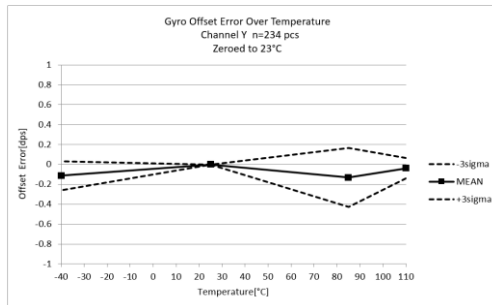


Chart 3 Gyro Offset Error over temperature Y-axis

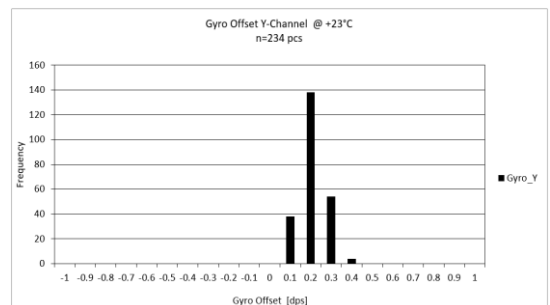


Chart 4 Gyro Offset Error @ +23°C Y-axis

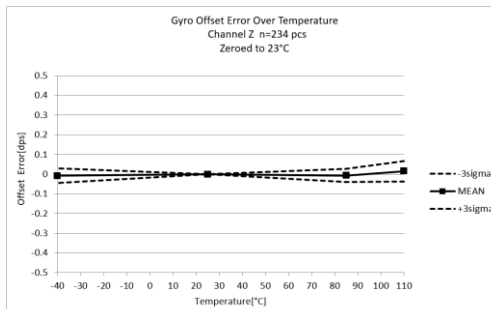


Chart 5 Gyro Offset Error over temperature Z-axis

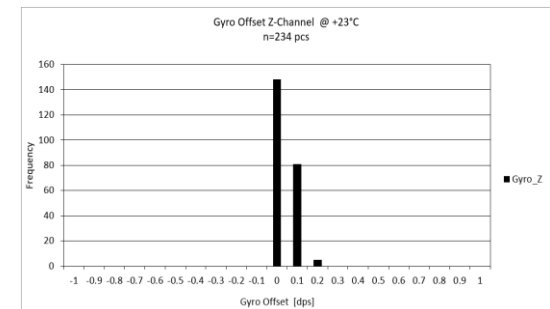


Chart 6 Gyro Offset Error @ +23°C Z-axis

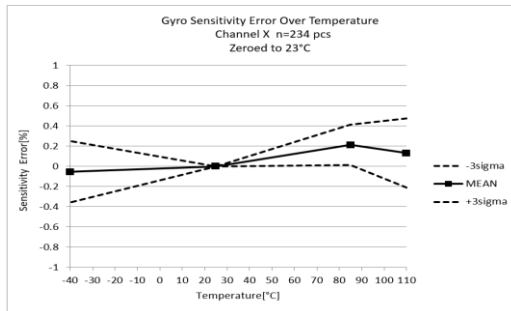


Chart 7 Gyro Sensitivity Error over temperature X-axis

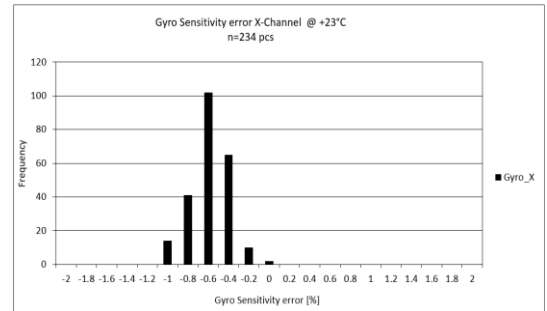


Chart 8 Gyro Sensitivity Error @ +23°C X-axis

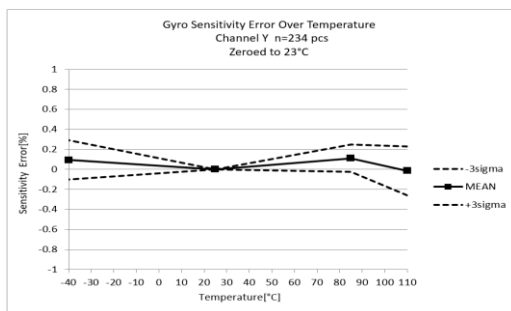


Chart 9 Gyro Sensitivity Error over temperature Y-axis

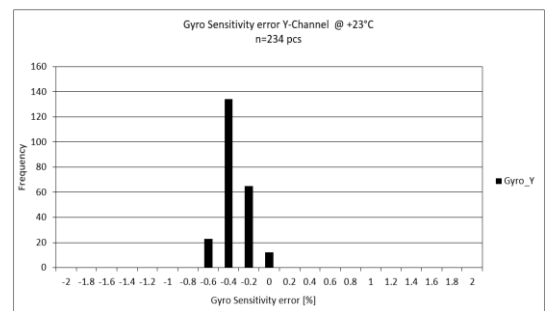


Chart 10 Gyro Sensitivity Error @ +23°C Y-axis

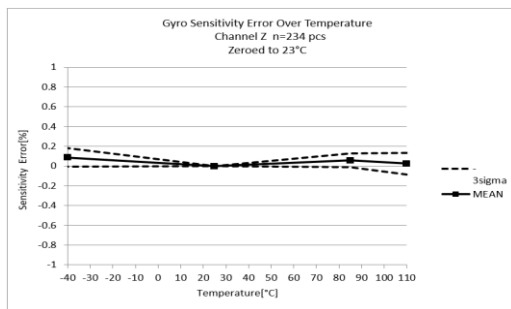


Chart 11 Gyro Sensitivity Error over temperature Z-axis

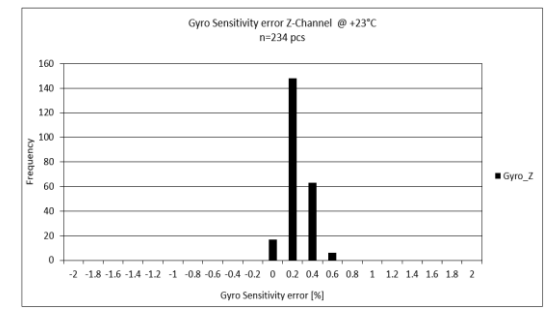


Chart 12 Gyro Sensitivity Error @ +23°C Z-axis

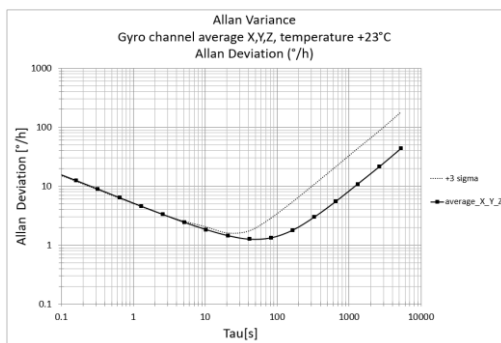


Chart 13 Gyro Allan Deviation X-, Y, and Z-axis

## 2.9.2 Acceleration typical characteristics

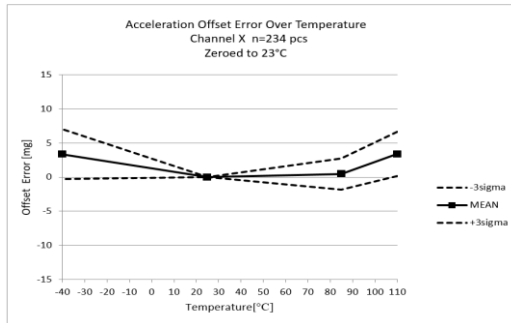


Chart 14 Accelerometer offset error over temperature X-axis

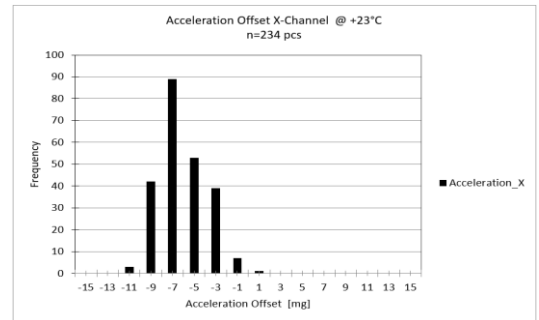


Chart 15 Accelerometer Offset Error @ +23°C X-axis

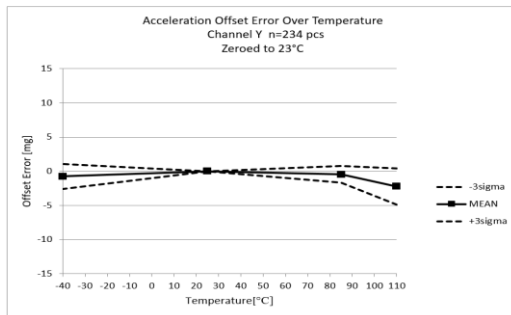


Chart 16 Accelerometer offset error over temperature Y-axis

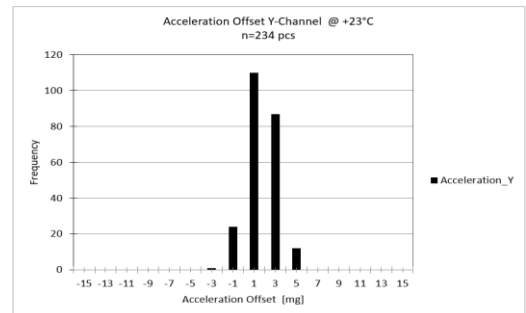


Chart 17 Accelerometer Offset Error @ +23°C Y-axis

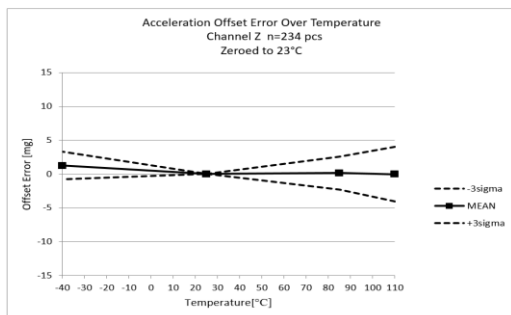


Chart 18 Accelerometer offset error over temperature Z-axis

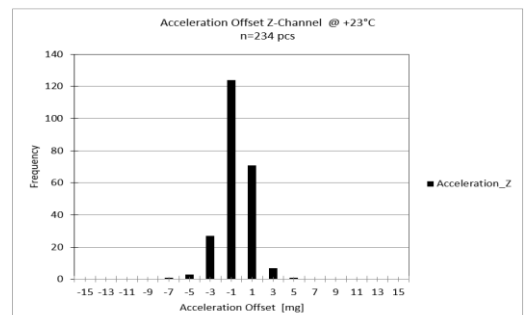


Chart 19 Accelerometer Offset Error @ +23°C Z-axis

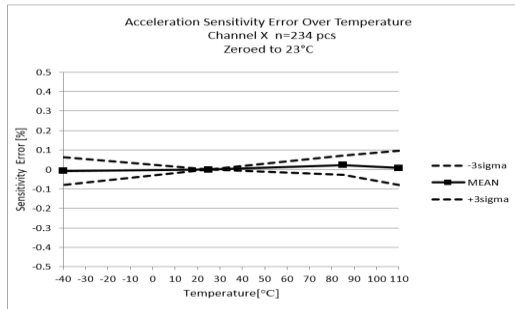


Chart 20 Accelerometer Sensitivity Error over temperature X-axis

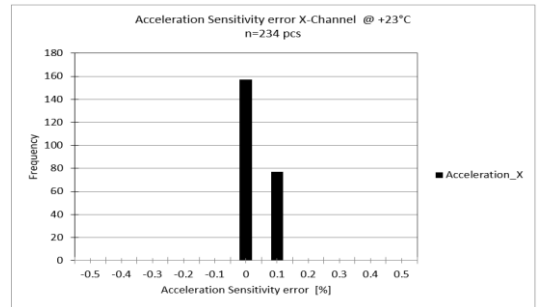


Chart 21 Accelerometer Sensitivity Error @ +23°C X-axis

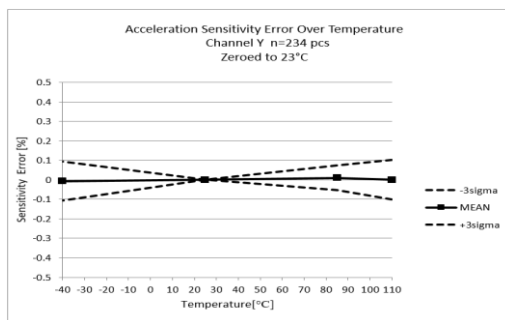


Chart 22 Accelerometer Sensitivity Error over temperature Y-axis

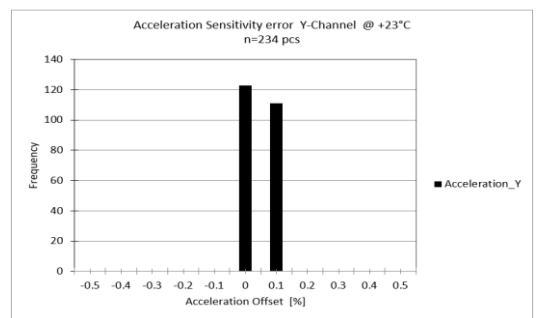


Chart 23 Accelerometer Sensitivity Error @ 23°C Y-axis

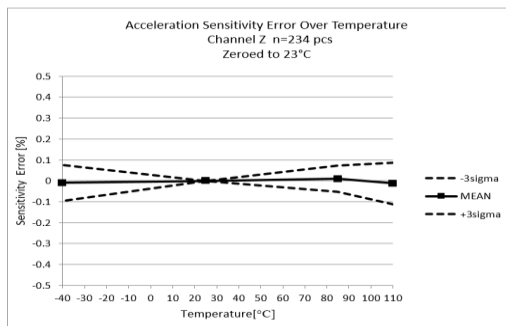


Chart 24 Accelerometer Sensitivity Error over temperature Z-axis

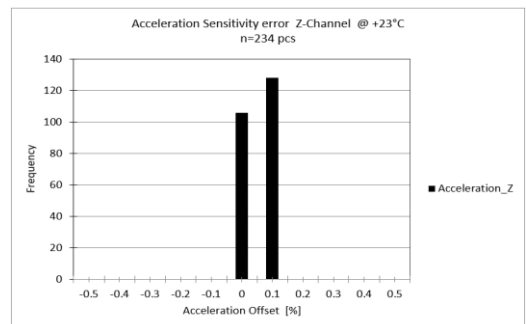


Chart 25 Accelerometer Sensitivity Error @ 23°C Z-axis

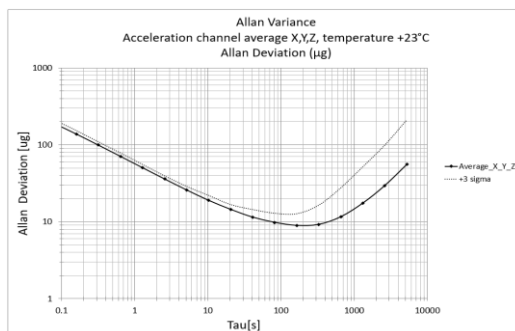


Chart 26 Acceleration Allan Deviation X-,Y- and Z-axis

## 2.10 Digital I/O Specification

Table 8 describes the DC characteristics of SCHA63T-K03 sensor SPI I/O pins. Supply voltage is 3.3 V unless otherwise specified. Current flowing into the circuit has a positive value.

**Table 8. SPI DC characteristics.**

| Symbol                                       | Description  | Min.      | Nom. | Max.      | Unit |
|--|--|-----------|------|-----------|------|
| <b>Serial Clock SCLK</b>                     |  |           |      |           |      |
| VinHigh                                      | Input high voltage   | 2         |      | V3p3D+0.3 | V    |
| VinLow                                       | Input low voltage  | -0.3      |      | 0.8       | V    |
| Vhy  | Input hysteresis   | 0.2       |      |           | V    |
| Isource                                      | Input current source (Pull down)   | 24        |      | 36        | uA   |
| Cin  | Input capacitance  |           |      | 6         | pF   |
| <b>Chip select CSB (Pull Up), low active</b> |  |           |      |           |      |
| VinHigh                                      | Input high voltage   | 2         |      | V3p3D+0.3 | V    |
| VinLow                                       | Input low voltage  | -0.3      |      | 0.8       | V    |
| Vhy  | Input hysteresis   | 0.2       |      |           | V    |
| Isource                                      | Input current source (Pull Up), Vin = 0V   | 24        |      | 36        | uA   |
| Cin  | Input capacitance  |           |      | 6         | pF   |
| Vin_open                                     | Open circuit output voltage  | 2         |      |           | V    |
| <b>Serial data input MOSI (Pull Down)</b>    |  |           |      |           |      |
| VinHigh                                      | Input high voltage   | 2         |      | V3p3D+0.3 | V    |
| VinLow                                       | Input low voltage  | -0.3      |      | 0.8       | V    |
| Vhy  | Input hysteresis   | 0.2       |      |           | V    |
| Isource                                      | Input current source (Pull Up), Vin = DVDD   | 24        |      | 36        | uA   |
| Cin  | Input capacitance  |           |      | 6         | pF   |
| Vin_open                                     | Open circuit output voltage  |           |      | 0.3       | V    |
| <b>Serial data output MISO (Tri state)</b>   |  |           |      |           |      |
| VoutHigh_-1mA                                | Output high voltage, Iout = -1mA   | V3p3D-0.5 |      |           | V    |
| VinHigh_1mA                                  | Output low voltage, Iout = +1mA  |           |      | 0.5       | V    |
| Iout_Hz                                      | High impedance output current, 0V < VMISO < V3p3D  | -1        |      | 1         | uA   |
| Cld_miso                                     | Capacitive load. The slope of the MISO output signal can be controlled to meet EMI requirements under specified load conditions. |           |      | 200       | pF   |

**Table 9. EXTRESN pin characteristics**

| Symbol                     | Description                        | Min. | Nom. | Max.      | Unit |
|----------------------------|------------------------------------|------|------|-----------|------|
| <b>Digital pin EXTRESN</b> |                                    |      |      |           |      |
| VinHigh                    | Input high voltage                 | 2    |      | V3p3A+0.3 | V    |
| VinLow                     | Input low voltage                  | -0.3 |      | 0.8       | V    |
| Vhy                        | Input hysteresis                   | 0.2  |      |           | V    |
| Isource                    | Start-up indication phase inactive | 60   |      | 160       | uA   |
|                            | Start-up indication phase active   | 30   |      | 80        | uA   |

## 2.11 SPI AC Characteristics

The AC characteristics of SCHA63T-K03 are defined in Figure 2 and Table 10.

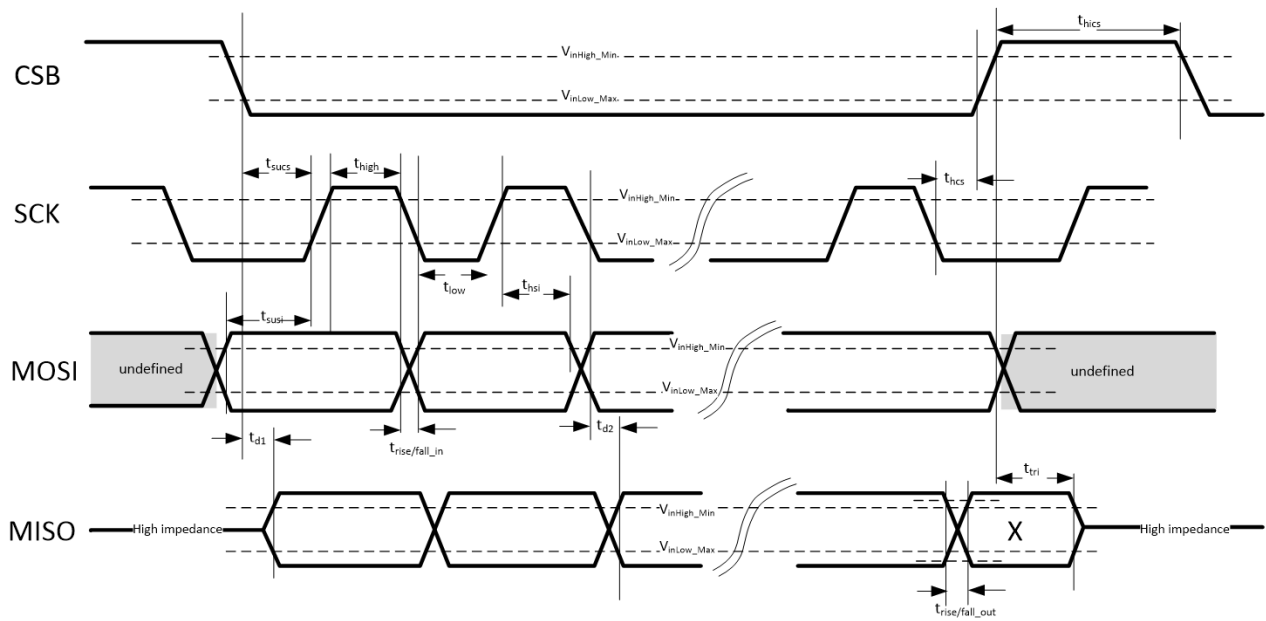


Figure 2. Timing diagram of SPI communication.

Table 10. SPI AC electrical characteristics.

| Symbol        | Description   | Min. | Nom.    | Max.          | Unit |
|---------------|---|------|---------|---------------|------|
| fSPI          | Master (MCU):<br>SPI SCLK frequency   | 0.1  | -       | 10            | MHz  |
| tSPI          | Master (MCU):<br>SPI SCLK period  | -    | 1/ fSPI | -             | -    |
| thigh         | Master (MCU):<br>High time: duration of logical high level<br>at SCLK (from VinHigh_min to<br>VinHigh_min)  | 35   | tSPI/2  | -             | ns   |
| tlow          | Master (MCU):<br>Low time: duration of logical low level at<br>SCLK (from VinLow_max to<br>VinLow_max)  | 35   | tSPI/2  | -             | ns   |
| tsucs         | Master (MCU):<br>Setup time CSB: time between the<br>falling edge of CSB and the rising edge<br>of SCLK (from VinLow_max to<br>VinLow_max)                        | 40   | tSPI/2  | -             | ns   |
| tsusi         | Master (MCU):<br>Setup time at MOSI: setup time of<br>MOSI before the rising edge of SCLK<br>(from VinLow_max to VinLow_max or<br>from VinHigh_min to VinLow_max) | 10   | -       | -             | ns   |
| thsi          | Master(MCU):<br>Hold time at MOSI: hold time of MOSI<br>after rising edge of SCLK (from<br>VinHigh_min to VinLow_max or to<br>VinHigh_min)                        | 20   | -       | -             | ns   |
| thcs          | Master (MCU):<br>Hold time of CSB: time between the<br>falling edge of SCLK and the rising<br>edge of CSB (from VinLow_max to<br>VinLow_max)                      | 30   | tSPI/2  | -             | ns   |
| thics         | Master (MCU):<br>Minimum high time of CSB between<br>two consecutive transfers (from<br>VinHigh_min to VinHigh_min)   | 30   | tSPI/2  | -             | ns   |
| trise/fall_in | Master (MCU):<br>Rise/fall time of SCK/MOSI signals<br>(from VinLow_max to VinHigh_min or<br>from VinHigh_min to VinLow_max)                                      | -    | -       | 0.15x<br>tSPI | ns   |
| td1           | Slave(=SCHA63T-K03 ASIC):<br>Delay time: time delay from the falling<br>edge of CSB to data valid at MISO<br>(from VinLow_max to VinLow_max or<br>to VinHigh_min) | -    | -       | 30            | ns   |

|                |   |   |    |    |    |
|----------------|---|---|----|----|----|
| td2            | Slave(=SCHA63T-K03 ASIC):<br>Delay time: time delay from falling edge of SCLK to data valid at MISO (from VinLow_max to VInLow_max or to VInHigh_min)                         | 0 | -  | 30 | ns |
| ttri           | Slave(=SCHA63T-K03 ASIC):<br>Tri-state delay time: time between the rising edge of CSB to MISO in Tri-state (from VinHigh_min to X)   | - | -  | 25 | ns |
| trise/fall_out | Slave(=SCHA63T-K03 ASIC): Rise/fall time of MISO signal (VOut_10% to VOut_90% and from VOut_90% to VOut_10%)<br>User selectable MISO slew rate control in Mode register (19h) | 4 | 10 | 16 | ns |

## 2.12 Measurement Axis and Directions

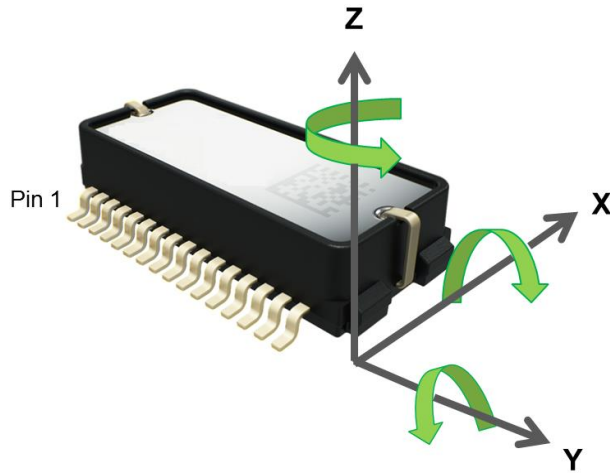


Figure 3. SCHA63T-K03 measurement directions.

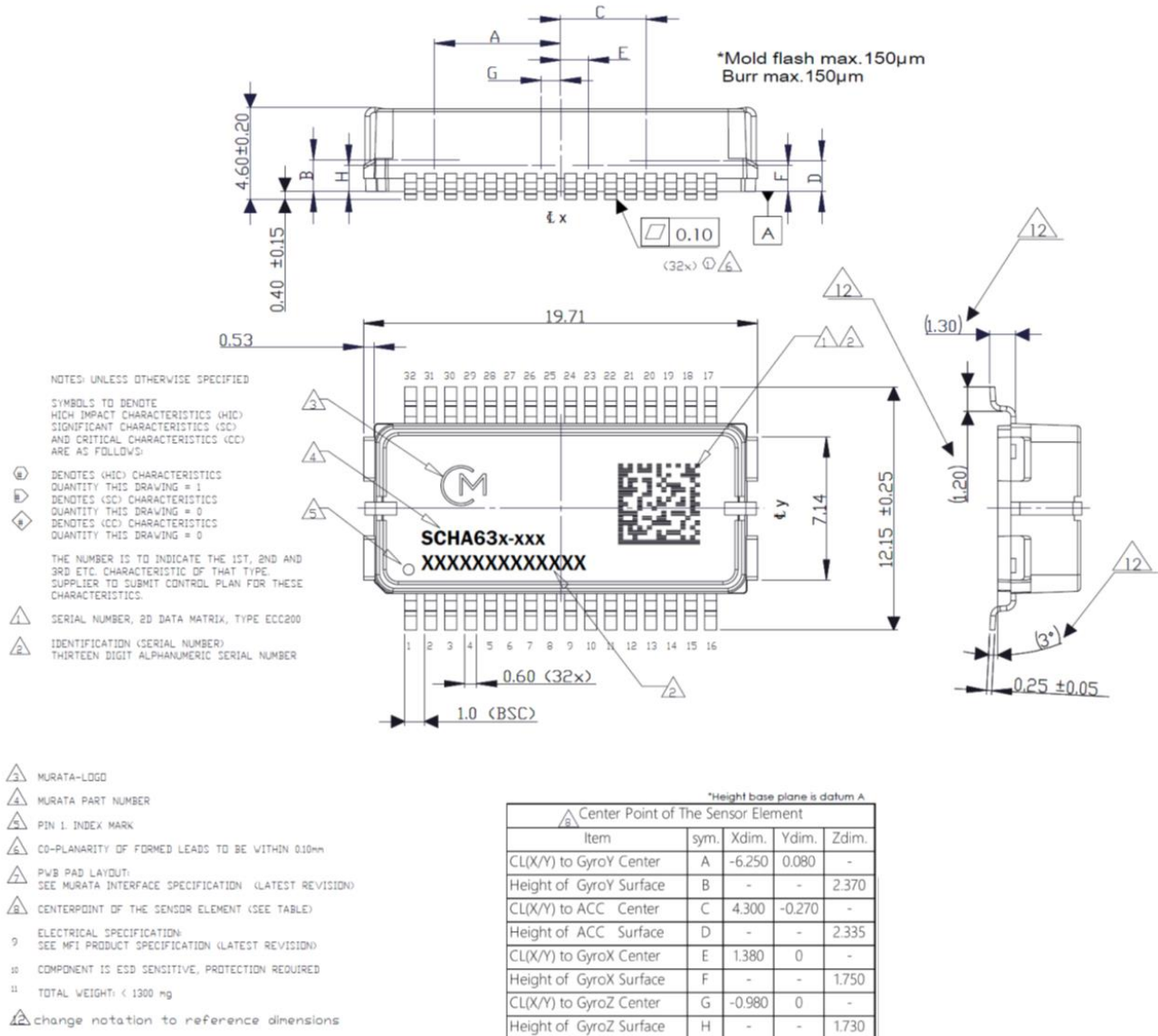
Table 11 SCHA63T-K03 accelerometer measurement directions and outputs

| X: 0g      0LSB<br>Y: 0g      0LSB<br>Z: 1g      4905LSB | X: -1g     -4905LSB<br>Y: 0g      0LSB<br>Z: 0g      0LSB | X: 0g      0LSB<br>Y: 0g      0LSB<br>Z: -1g     -4905LSB |
|--|---|---|
|  |   |   |
| X: 0g      0LSB<br>Y: 1g      4905LSB<br>Z: 0g      0LSB | X: 1g      4905LSB<br>Y: 0g      0LSB<br>Z: 0g      0LSB  | X: 0g      0LSB<br>Y: -1g     -4905LSB<br>Z: 0g      0LSB |

**2.13 Package Characteristics**

**2.13.1 Package Outline Drawing**

The SCHA63T-K03 package outline and dimensions are presented in The outline of the SCHA63T-K03 package (SOIC-32) in mm. and Table 12. Limits for linear measures (ISO2768-f) unless tolerance is not specified in Figure 4 The outline of the SCHA63T-K03 package (SOIC-32) in mm.



**Figure 4 The outline of the SCHA63T-K03 package (SOIC-32) in mm.**

**Table 12. Limits for linear measures (ISO2768-f) unless tolerance is not specified in Figure 4 The outline of the SCHA63T-K03 package (SOIC-32) in mm.**

| Tolerance class | Limits in mm for nominal size in mm |              |               |                 |
|-----------------|-------------------------------------|--------------|---------------|-----------------|
|                 | 0.5 to 3                            | Above 3 to 6 | Above 6 to 30 | Above 30 to 120 |
| f (fine)        | ±0.05                               | ±0.05        | ±0.1          | ±0.15           |

It is not applicable for number shown in table of center point of the sensor element in figure 4, which is only for reference.

## 2.14 PCB Footprint

SCHA63T-K03 footprint dimensions are presented in Figure 5. Recommended PWB pad layout for SCHA63T-K03.

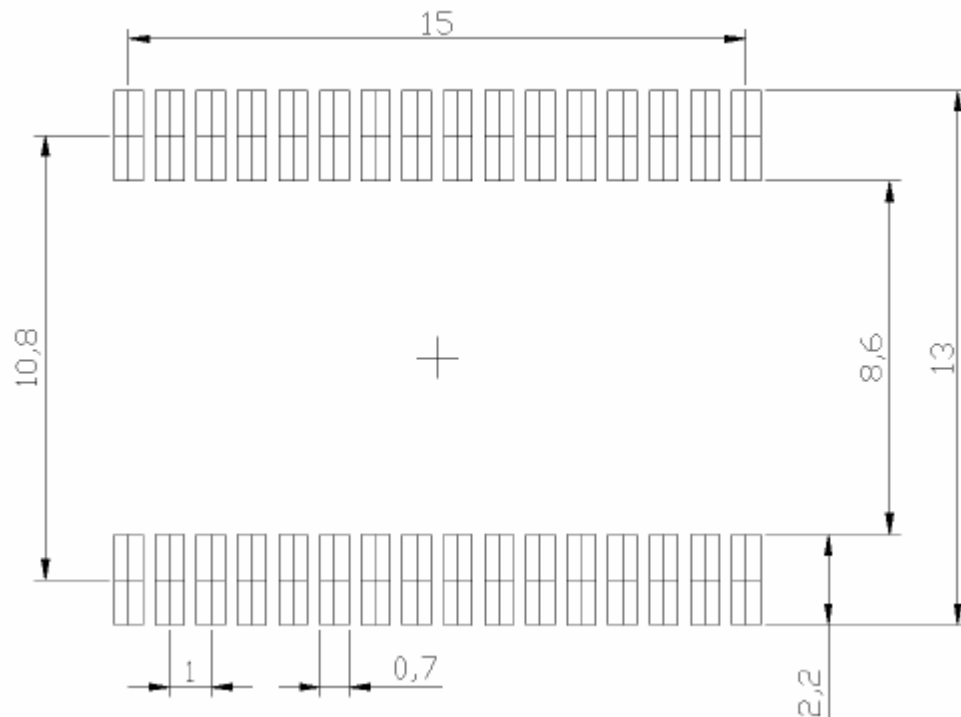


Figure 5. Recommended PWB pad layout for SCHA63T-K03.

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- ✓ Cost Control Management
- ✓ Shortage Management
- ✓ Alternative Solution
- ✓ Excess Inventory Management