

Accelerometer for RS-422-Interface

M-A552AR1x

Data Sheet

(P/N: X2F000031000300)

Notice of the Document

NOTICE : PLEASE READ CAREFULLY BELOW BEFORE THE USE OF THIS DOCUMENT ©Seiko Epson Corporation 2022

The content of this document is subject to change without notice.

1. This document may not be copied, reproduced, or used for any other purposes, in whole or in part, without the consent of Seiko Epson Corporation (“Epson”).
2. Before purchasing or using Epson products, please contact with our sales representative for the latest information and be always sure to check the latest information published on Epson’s official web sites and sources.
3. Information provided in this document such as application circuits, programs, usage, etc., are for reference purpose only. Please use the application circuits, programs, usage, etc. in the design of your equipment or systems at your own responsibility. Epson makes no guarantees against any infringements or damages to any third parties’ intellectual property rights or any other rights resulting from the information. This document does not grant you any licenses, intellectual property rights or any other rights with respect to Epson products owned by Epson or any third parties.
4. Epson is committed to constantly improving quality and reliability, but semiconductor products in general are subject to malfunction and failure. In using Epson products, you shall be responsible for safe design in your products; your hardware, software and systems are designed enough to prevent any harm or damages to life, health or property even if any malfunction or failure might be caused by Epson products. In designing of your products with using Epson products, please be sure to check and comply with the latest information regarding Epson products (this document, specifications, data sheets, manuals, Epson’s web site, etc.). When using the information included in the above materials such as product data, chart, technical contents, programs, algorithms and application circuit examples, you shall evaluate your products both in stand-alone basis and within your overall systems. You shall be solely responsible for deciding whether or not to adopt and use Epson products.
5. Epson has prepared this document and programs provided in this document carefully to be accurate and dependable, but Epson does not guarantee that the information and the programs are always accurate and complete. Epson assumes no responsibility for any damages which you incurred by due to misinformation in this document and the programs.
6. No dismantling, analysis, reverse engineering, modification, alteration, adaptation, reproduction, etc., of Epson products is allowed.
7. Epson products have been designed, developed and manufactured to be used in general electronic applications (office equipment, communications equipment, measuring instruments, home electronics, etc.) and applications individually listed in this document (“General Purpose”). Epson products are NOT intended for any use beyond the General Purpose that requires particular/higher quality or reliability in order to refrain from causing any malfunction or failure leading to harm to life, health or serious property damage or severe impact on society, including, but not limited to listed below. Therefore, you are advised to use Epson products only for the General Purpose. Should you desire to buy and use Epson products for the particular purpose other than the General Purpose, Epson makes no warranty and disclaims with respect to Epson products, whether express or implied, including without limitation any implied warranty of merchantability or fitness for any particular purpose.
【Particular purpose】
Space equipment (artificial satellites, rockets, etc.)
Transportation vehicles and their control equipment (automobiles, aircraft, trains, ships, etc.)
Medical equipment (other than applications individually listed in this document) / Relay equipment to be placed on sea floor
Power station control equipment / Disaster or crime prevention equipment / Traffic control equipment / Financial equipment
Other applications requiring similar levels of reliability as the above
8. Epson products listed in this document and our associated technologies shall not be used in any equipment or systems that laws and regulations in Japan or any other countries prohibit to manufacture, use or sell. Furthermore, Epson products and our associated technologies shall not be used for developing military weapons of mass destruction, military purpose use, or any other military applications. If exporting Epson products or our associated technologies, you shall comply with the Foreign Exchange and Foreign Trade Control Act in Japan, Export Administration Regulations in the U.S.A (EAR) and other export-related laws and regulations in Japan and any other countries and follow the required procedures as provided by the relevant laws and regulations.
9. Epson assumes no responsibility for any damages (whether direct or indirect) caused by or in relation with your non-compliance with the terms and conditions in this document.
10. Epson assumes no responsibility for any damages (whether direct or indirect) incurred by any third party that you assign, transfer, loan, etc., Epson products.
11. For more details or other concerns about this document, please contact our sales representative.
12. Company names and product names listed in this document are trademarks or registered trademarks of their respective companies.

2022.08

© Seiko Epson Corporation 2022-2023. All rights reserved.

Table of Contents

1. GENERAL DESCRIPTION	1
1.1. FEATURES.....	1
1.2. APPLICATIONS.....	2
1.3. BLOCK DIAGRAM	2
2. SPECIFICATIONS	3
2.1. ABSOLUTE MAXIMUM RATINGS.....	3
2.2. RECOMMENDED OPERATING CONDITION	3
2.3. PERFORMANCE & ELECTRICAL SPECIFICATIONS	4
3. MECHANICAL DIMENSIONS	7
3.1. OUTLINE DIMENSIONS.....	7
3.2. CONNECTOR SPECIFICATIONS.....	8
4. TYPICAL PERFORMANCE CHARACTERISTICS	10
5. CONNECTION EXAMPLE	11
5.1. CONNECTION TO HOST	11
5.2. PRECAUTION FOR WIRING AND CABLING	11
5.3. PRECAUTION FOR SUPPLYING POWER	11
5.4. OPERATION MODE	12
5.5. STATE TRANSITION	13
5.6. Functional Block	14
5.7. Sampling Counter	14
5.8. Self Test	14
5.9. Threshold Detection of Accelerometer	15
5.10. Checksum	15
5.11. Automatic Start (For UART Auto Sampling Only).....	16
5.12. Bias Offset	16
5.13. Tilt Output / Combination Output	16
5.14. Measurement with Reduced Noise Floor Condition.....	17
5.15. Bias Temperature Shock Compensation.....	17
5.16. FILTER 17	
5.16.1. FIR Kaiser Filter	17
5.16.2. User FIR Filter.....	21
5.16.3. Notes For FIR Filter Usage.....	23
5.16.4. Long-Term Filter (HPF, LPF)	24
6. HOST INTERFACE	25
6.1. SERIAL INTERFACE SPECIFICATION	25
6.1.1. COMUNICATION CONDITION	25

6.1.2.	UART Read Timing (Normal Mode).....	26
6.1.3.	UART Read Timing (Burst Mode).....	27
6.1.4.	UART Write Timing.....	27
6.1.5.	UART Auto Sampling Operation.....	28
6.2.	Data Packet Format.....	29
7.	User Registers.....	30
7.1.	BURST Register (Window 0).....	32
7.2.	MODE_CTRL Register (Window 0).....	33
7.3.	DIAG_STAT Register (Window 0).....	33
7.4.	FLAG(ND/EA) Register (Window 0).....	35
7.5.	COUNT Register (Window 0).....	36
7.6.	TEMP Register (Window 0).....	37
7.7.	ACCL Register (Window 0).....	37
7.8.	TILT Register (Window 0).....	38
7.9.	SIG_CTRL Register (Window 1).....	38
7.10.	MSC_CTRL Register (Window 1).....	39
7.11.	SMPL_CTRL Register (Window 1).....	41
7.12.	FILTER_CTRL Register (Window 1).....	42
7.13.	UART_CTRL Register (Window 1).....	43
7.14.	GLOB_CMD Register (Window 1).....	44
7.15.	BURST_CTRL Register (Window 1).....	44
7.16.	FIR_UCMD Register (Window 1).....	45
7.17.	FIR_UDATA Register (Window 1).....	46
7.18.	FIR_UADDR Register (Window 1).....	46
7.19.	LONGFILT_CTRL Register (Window 1).....	47
7.20.	LONGFILT_TAP Register (Window 1).....	47
7.21.	XA_OFFSET Register (Window 1).....	48
7.22.	YA_OFFSET Register (Window 1).....	48
7.23.	ZA_OFFSET Register (Window 1).....	49
7.24.	XA_ALARM Register (Window 1).....	49
7.25.	YA_ALARM Register (Window 1).....	50
7.26.	ZA_ALARM Register (Window 1).....	50
7.27.	PROD_ID Register (Window 1).....	51
7.28.	VERSION Register (Window 1).....	51
7.29.	SERIAL_NUM Register (Window 1).....	51
7.30.	WIN_CTRL Register (Window 0,1).....	52
8.	SAMPLE PROGRAM FLOW.....	53
8.1.	FLOW.....	53
8.1.1.	Power-on sequence.....	53
8.1.2.	Register read and write.....	53
8.1.3.	Sampling data.....	54

8.1.4.	Self test	55
8.1.5.	Flash Test	56
8.1.6.	Software Reset	56
8.1.7.	Flash Backup	57
8.1.8.	Flash Reset.....	57
8.1.9.	Filter setting	58
8.1.10.	User Defined FIR Filter coefficients setting	59
8.1.11.	Auto Start.....	60
9.	HANDLING NOTES.....	62
9.1.	CAUTIONS FOR ATTACHING.....	62
9.2.	OTHER CAUTIONS.....	62
9.3.	LIMITED WARRANTY	63
10.	PART NUMBER / ORDERING INFO.....	64
11.	STANDARDS AND APPROVALS	65
11.1.	NOTICE 65	
11.2.	CE Statement	65
11.3.	RoHS & WEEE	65
11.4.	UKCA Statement	66
11.5.	FCC Compliance Statement for American users	66
11.6.	Industry ICES Compliance Statement for Canadian users.....	66
12.	REVISION HISTORY	67

1. GENERAL DESCRIPTION

The M-A552 is a three axis digital output accelerometer featuring ultra-low noise, high stability, and low power consumption using fine processing technology of Quartz. Incorporating both high accuracy and durability, the versatile M-A552 is well suited to a wide-range of challenging applications such as SHM, seismic observation, condition monitoring for industrial equipment, and pose detection for industrial machinery (i.e. construction machinery/attachments, agricultural machinery/ implements, robots). The M-A552 is packaged in a water-proof and dust-proof metallic case supporting RS422 interface. This ruggedized unit is suitable for industrial use that requires remote mounting, or long-distance wiring.

1.1. FEATURES

Table 1-1 Features

Item	Specification	Note
Sensor		
Integrated sensor	Model: M-A552AR1x Internal sensor M-A352 Output range $\pm 15G$ Initial Bias error $\pm 4mG (@25^{\circ}C)$ Resolution 0.06 μG Low noise 0.5 $\mu g/\sqrt{Hz}$ typ. Selectable output format: Acceleration / Tilt Angle Programmable low-pass digital filters	
Interface		
Protocol (DL layer)	RS-422 (TX/RX Pair, Full-Duplex transmission)	
Bit rate	Maximum 460.8kbps (programmable)	230.4kbps(default)
Cable Length	250m (max)	
Others		
Trigger function	Internal timer event trigger function	External trigger not available
Terminator	Included (120 Ω typ)	
General specification		
Voltage supply	9 ~ 32V	
Power consumption	40mA typ. ($V_{in}=12V$)	
Operating temperature range	-30 ~ +70 $^{\circ}C$	
External dimension		
Outer packaging	Overall metallic shield case	
Size	65x60x30 mm (Including projection)	
Weight	128g	
Interface connector	M12, 8pin-male, water-proof	
Water-proof, Dust-proof	IP67	
Regulation		
EU	CE marking (EN61326, RoHS Directive)	Class A
FCC	FCCpart15B	Class A

1.2. APPLICATIONS

- Structural health monitoring
- Seismic measurements
- Vibration control and stabilization
- Motion analysis and control

1.3. BLOCK DIAGRAM

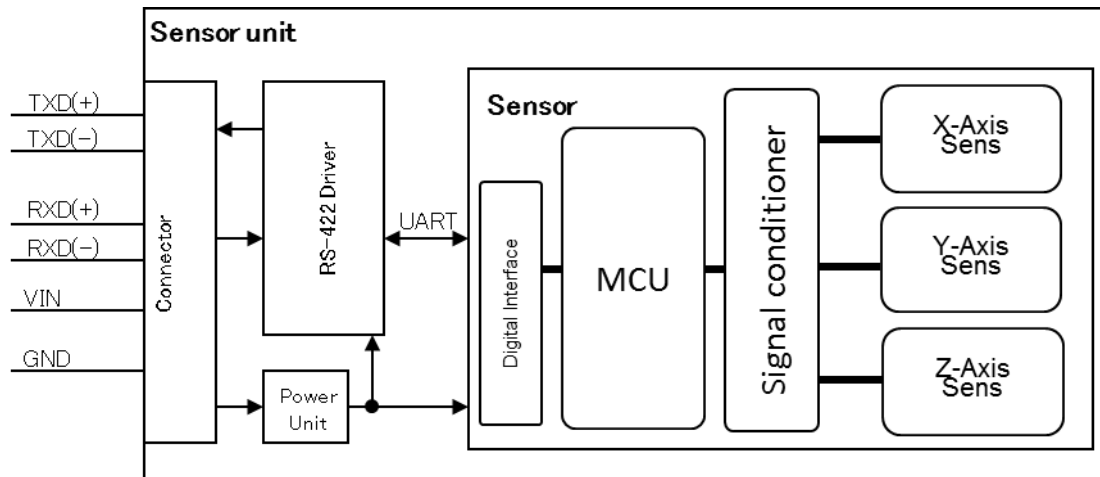


Figure 1-1 Block Diagram

2. SPECIFICATIONS

2.1. ABSOLUTE MAXIMUM RATINGS

Table 2-1 Absolute Maximum Ratings

Parameter	Min	Typ.	Max	Unit
V _{IN} to GND	-0.3		+32	V
Voltage on any pin to GND	-32		+32	V
Storage Temperature Range	-40		85	°C
Operating Temperature Range	-30		70	°C
Shock Resistance (Half-sine 1msec) *1			1,000	G

If the unit is operated beyond the absolute maximum rating, malfunction may occur, or the unit may fail completely. Although the unit may appear to operate normally, reliability may decrease.

CAUTION:

***1 Excessive vibration or shock independent of the above listed conditions may increase the possibility of malfunction or causing a failure!**

2.2. RECOMMENDED OPERATING CONDITION

Table 2-2 Recommended Operating Conditions

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Power supply voltage	V _{IN}	V _{IN} to GND *2	9 *1	12	24	V
Port input voltage	V _{PORT}	RD+/RD- to GND		5		V
Operating temperature	T _{OPE}		-20	-	70	°C

*1. *When power supply voltage is 9V or less, the master may not be able to communicate with this node normally even if the LED turns on.

*2. The power supply voltage must reach the recommended operating condition within 2 seconds after power is applied to this node.

2.3. PERFORMANCE & ELECTRICAL SPECIFICATIONS

Table 2-3 Sensor Specifications (Common Items)

VIN=12V, TA=-30°C to +70°C, ±1G unless otherwise noted

Parameter	Test Conditions / Comments	Min	Typ.	Max	Unit
MISALIGNMENT					
Case to Axis				±0.5	Deg
Axis to Axis	1 σ, Axis-to-axis, Δ = 90° ideal, RT			±0.1	Deg
Cross Axis Sensitivity			±0.2		%
ACCELERATION^{*1}					
Sensitivity					
Output Range				±15	G
Scale Factor			0.06		μG/LSB
Sensitivity Error	25°C, ≤ 1G		±500		ppm
Nonlinearity	≤ 1G, Best fit straight line, RT			±0.03	% of FS
Bias					
Initial Error	1 σ, -30°C ≤ TA ≤ +70°C			±4	mG
Bias Repeatability	TA=25°C, VIN=12V For 1 year after shipment		3		mG
Bias Temperature Error	25°C			±2	mG
Temperature sensitivity			±0.1		mG/°C
Bias Instability	AVR, Average		0.2		uG
Velocity Random Walk	Average		1.2E-4		(m/sec)/√hr
Noise					
Noise Density	TA=25°C, average 0.5Hz to 6Hz,		0.5	2	μG/√Hz
	TA=25°C, peak 0.5Hz to 100Hz			60	μG/√Hz
Cantilever Resonance frequency	25°C, VIN=12V		850		Hz
VRC	at 50Hz 25°C, VIN=12V			±50	μG/G ²
Frequency Property					
-6 dB Bandwidth	User selectable	9		460	Hz
TILT ANGLE^{*2}					
Sensitivity					
Output Range				±1.0472 (±60)	rad (deg)
Scale Factor			0.002		μrad/LSB
Nonlinearity	25°C, ±45deg			±0.03	% of FS
Misalignment	1 σ, Axis-to-axis, Δ = 90° ideal			±1.745 (±0.1)	mrad (deg)
Bias					
Bias Repeatability	TA=25°C, VIN=12V For 1 year after shipment		±3 (±0.17)		mrad (deg)
Bias Temperature Error	25°C			±2 (±0.11)	mrad (deg)
Noise					
Noise Density	TA=25°C, average 0.5Hz to 6Hz,		0.5	2	μrad/√Hz, rms
TEMPERATURE SENSOR					
Output Range		-30		85	°C
Scale Factor ^{*3}	at 25°C T[°C]=SF*a+34.987		-0.0037918		°C/LSB

*1. The calibrated standard 1G gravitational acceleration value is 9.80665 m/s².

- *2. The tilt angle is internally calculated from gravitational acceleration by the following expression.
Tilt Angle Calculation Formula

$$\theta = \text{asin}(G) [\text{rad}]$$

- *3. This is a reference value used for the internal temperature correction, and is not guaranteed to accurately output the interior temperature.

Table 2-4 Interface Specification

T_A=25°C, V_{IN}=12V, unless otherwise noted

Parameter	Test Conditions	Min	Typ.	Max	Unit
Driver					
Differential Output Voltage	RL=120Ω, TD- to TD+	2	2.5		V
	RL=54Ω, TD- to TD+	1.5	2		V
Common Mode Output Voltage	RL=120Ω	1	2.5	3	V
Output Resistance			120		Ω
Rise or Fall Time	RL=120Ω			400	ns
Receiver					
Differential Input voltage		-25		25	V
Input Resistance			120		Ω
FUNCTIONAL TIMES (Time until data is available)					
Power-On Start-Up Time *1				900	ms
Reset Recovery Time *1				970	ms
Flash Backup Time				310	ms
Flash Reset Time				1900	ms
Self Test Time	ACC Test / TEMP Test / VDD Test			200	ms
	Sensitivity Test		10	40	s
	Flash Test			5	ms
Filter Setting Time	Built-In FIR Filter			4	ms
	User Defined FIR Filter			100	ms
User Filter Write Cycle, tUWC				7	ms
User Filter Read Cycle, tURC				500	us
OUTPUT DATA RATE *2		50		1,000	Sps
Clock Accuracy				±0.001	%

- *1. Do not access the device during startup or reinitialization.
 *2. Data rate and optimum filter characteristics can be changed by command.

Table 2-5 Current Consumption

T_A=25°C, RL=120Ω, unless otherwise specified; all voltages are defined with respect to ground; positive currents flow into the sensor unit.;

Parameter	Term	Condition	Min.	Typ.	Max.	Unit
Standby current	I _{N(ready)}	V _{in} =12V	-	34.5	-	mA
		V _{in} =24V	-	18.5	-	mA
Operating current		V _{in} =12V, 512Tap 460.8kbps, 1000sps	-	38	-	mA
Maximum input current	I _{N(max)}		-	-	60	mA

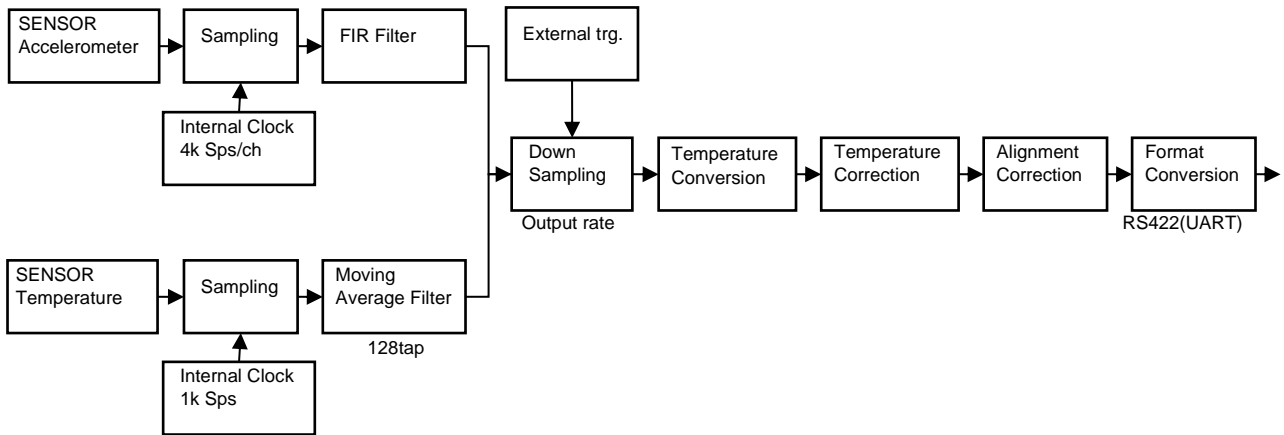


Figure 2-1 Functional Block Diagram

3. MECHANICAL DIMENSIONS

3.1. OUTLINE DIMENSIONS

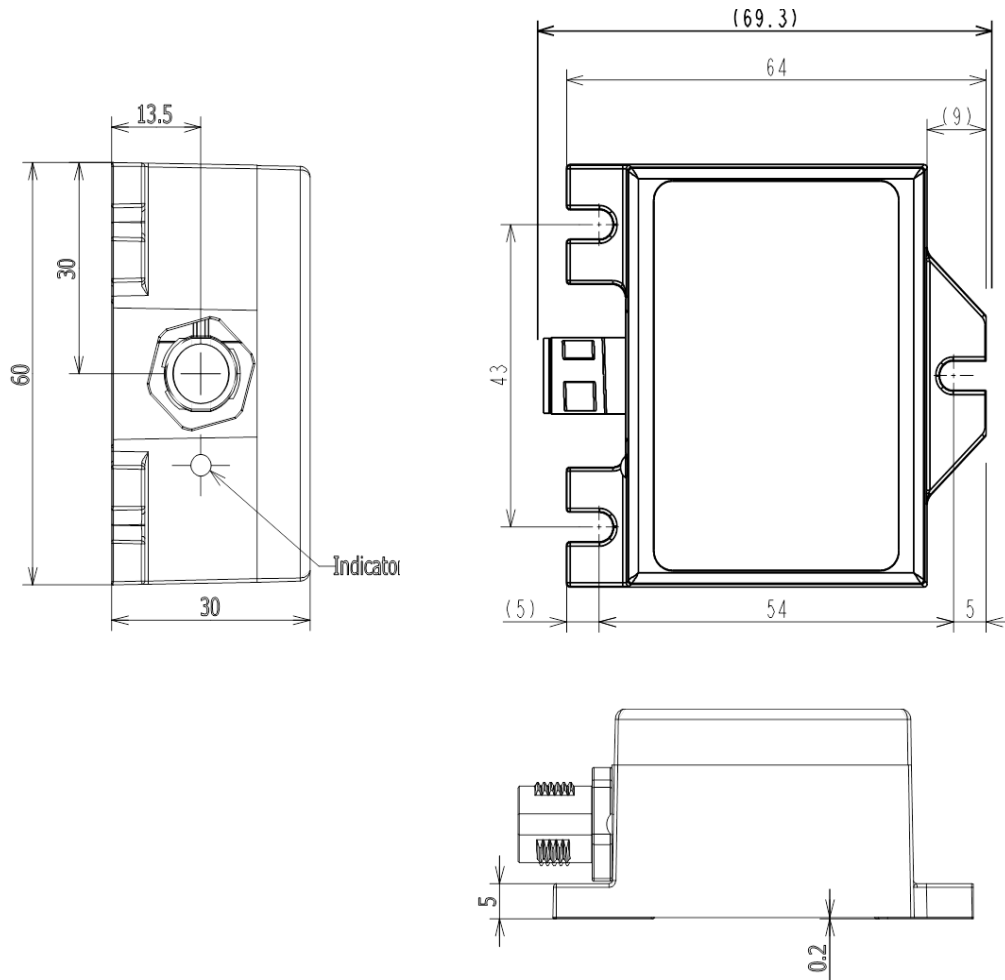


Figure 3-1 Outline Dimensions (millimeters)

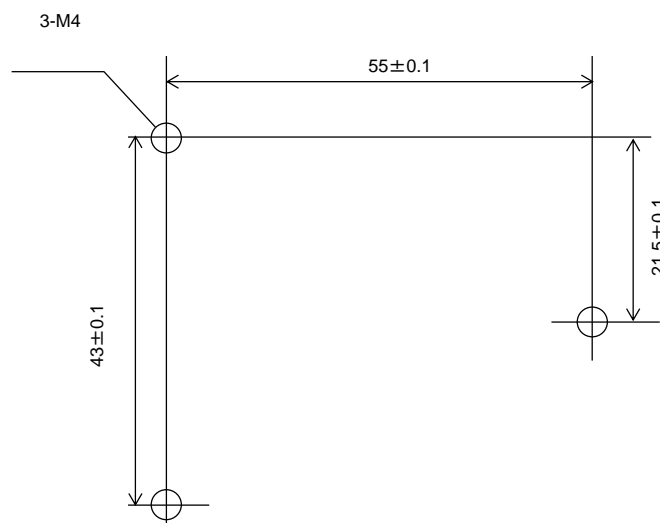


Figure 3-2 Recommended Mounting Dimension

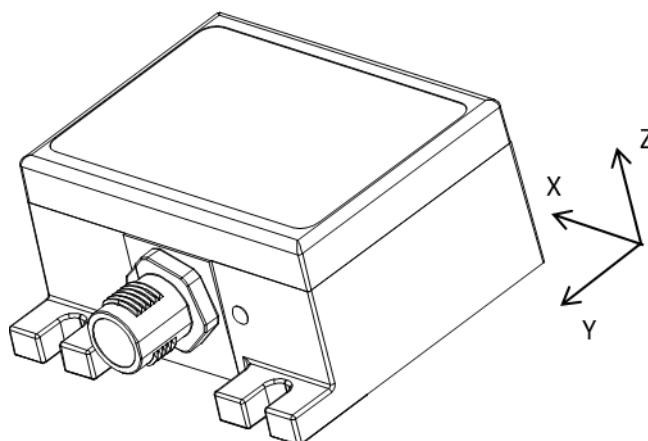


Figure 3-3 Axial direction

3.2. CONNECTOR SPECIFICATIONS

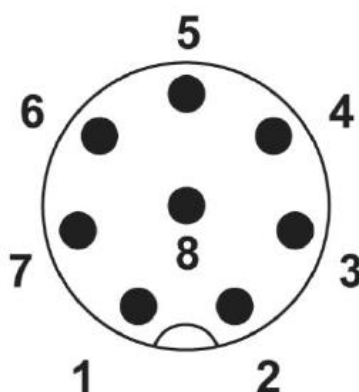


Figure 3-4 Connector Pin Layout

Table 3-1 Pin Function Description

Pin No.	Mnemonic	Type*1	Description
1	NC	N/A	Do Not Connect
2	VIN	S	Power Supply (9-32V)
3	GND	S	0V
4	TD-	O	Transmit Data (-)
5	RD+	I	Received Data (+)
6	TD+	O	Transmit Data (+)
7	NC	N/A	Do Not Connect
8	RD-	I	Received Data (-)

*1) Pin Type I :Input, O :Output, I/O :Input/Output, S :Supply, N/A :Not Applicable

Note: Please use an M12-8 pin mating female connector that corresponds to IP67 specifications.
Table 3-2 describes the connector manufacturer and the model number which is used in this product.

Table 3-2 Connector Part Number

MECHANICAL DIMENSIONS

Manufacturer	Part Number	RoHS Compliant
PHOENIX CONTACT	SACC-DSI-MS-8CON-M12-SCO SH	Yes

4. TYPICAL PERFORMANCE CHARACTERISTICS

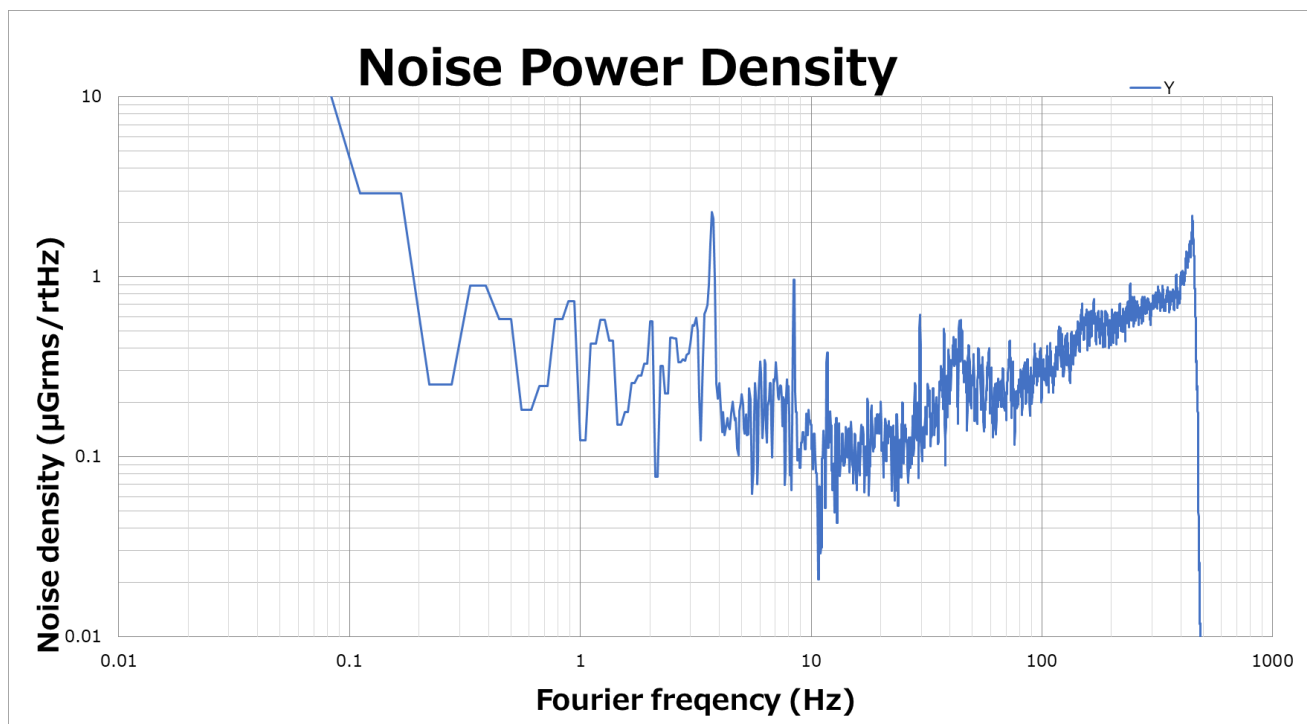


Figure 4-1 Noise Density Characteristics

The above graph is a typical example of the product characteristics, and is not guaranteed by the specification.

5. CONNECTION EXAMPLE

5.1. CONNECTION TO HOST

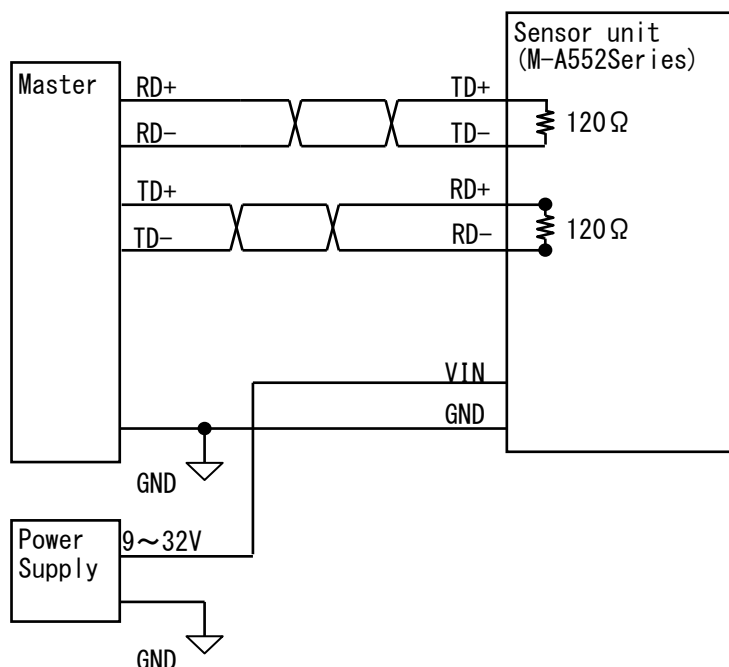


Figure 5-1 Connection Example

5.2. PRECAUTION FOR WIRING AND CABLING

- This product has internal terminator on the receiver port (RD).
- It is recommended that twisted pair cable with shielding should be used. Each signal pair should be connected to each cable pair. (ex: RD+ and RD-)
- It is recommended that shield connects to ground (at the host) when a cable with shield is used.
- Maximum recommended cable length is 250 meters as a guideline. However, even if the cable length is within the guidelines, the communication may be unstable or unusable depending on system environment. The cabling should be evaluated in the target system environment to confirm proper operation. (Ref: TIA-EIA-422-B ANNEX A)

5.3. PRECAUTION FOR SUPPLYING POWER

The user should be aware of serious risks on the power supply exposure to the following:

- High voltage noise by increased resistance and inductance on power supply line.
- Surge voltage from lightning and environmental equipment.

Figure 1-1Figure 5-2 describes the external reference protection circuit against the lightning surge with a surge level based on IEC61000-4-5, +/-1kV(power supply line to the power supply ground) and +/-2kV(power supply line to the earth).

VP:	CAN_V+ (Power supply)
PGND:	CAN_GND (Power supply ground)
FGND:	EARTH (System ground earth)
U3039:	Surge absorber to power supply (Okaya Electric Industries)
ERZ-V14D390:	Surge absorber to earth ground (Panasonic)

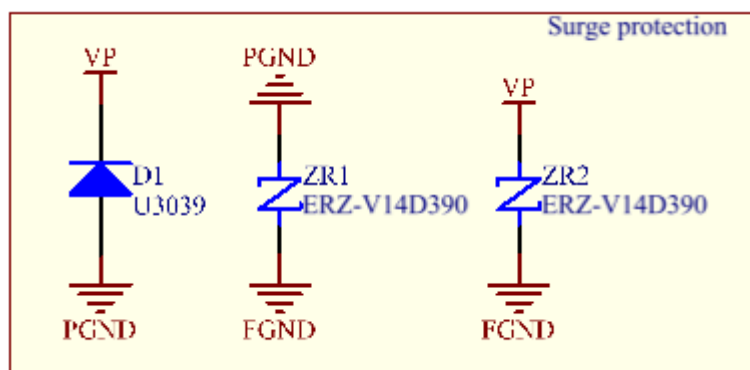


Figure 5-2 Surge Protection Circuit

5.4. OPERATION MODE

The following three operational modes are available in the device.

- 1) Configuration mode
- 2) Sampling mode

Sampling condition

- Manual sampling
- Auto sampling

Measurement condition

- Standard noise floor
- Reduced noise floor

In the Sampling mode, the device can operate with a standard noise floor condition or a reduced noise floor condition. When Auto sampling is active, all sensor outputs are sent automatically at the programmed output data rate without the request from the Host. These conditions can be switched between Manual sampling and Auto sampling by **UART_AUTO** ^{(*)3} (UART_CTRL[0x08(W1)] bit[0]), and between Standard noise floor and Reduced noise floor by **MESMOD_SEL** (see Figure 5.3).

Immediately after a hardware reset or power-on, internal initialization starts. During the internal initialization, all the register values and states of external pins are undefined. After the internal initialization is completed, the device goes into Configuration mode automatically, except when AUTO_START and UART_AUTO sampling are both enabled (the device then goes into Sampling mode automatically). To change the operation mode, write to **MODE_CMD** (MODE_CTRL[0x02(W0)] bit[9:8]) ^{(*)1} and make various changes to the sensor setting in Configuration mode ^{(*)2}. After configuration is completed, go to Sampling mode to read out the temperature and acceleration data.

By executing software reset (Register: GLOB_CMD [0x0A (W1)], write 1 to SOFT_RST in bit [7]), internal initialization operation is executed regardless of the current operation mode and the system enters Configuration mode.

*1. The following explains register notation used in this document.

For example, MODE_CTRL[0x02(W0)] bit[9:8] refers to:

- MODE_CTRL: Register Name
- [0x02(W0)]: First number is the Register Address, (W0) refers to Window Number "0"
- bit[9:8]: Bits from 9 to 8

*2. Make sure that the device is in Configuration mode when you write to the registers to configure operational settings. In Sampling mode, writing to registers is ignored **except** the following cases.

- Writing to **MODE_CMD** (MODE_CTRL[0x02(W0)] bit[9:8])
- Writing to **SOFT_RST** (GLOB_CMD[0x0A(W1)] bit[7])
- Writing to **WINDOW_ID** (WIN_CTRL[0x7E(W0/W1)] bit[7:0])

*3. While the device is with UART Auto sampling and sensor sampling is active, register read access is not supported. Otherwise, the sampling data transmitted with the UART Auto sampling will be corrupted by the response data from the register read.

5.5. STATE TRANSITION

Immediately after power-on, internal initialization starts and then the device will be in configuration mode. However, if AUTO_START and UART_AUTO are both enabled, then the device automatically enters sampling mode after internal initialization. Various operation modes are executed by sending various commands from configuration mode. Table 5.3 shows the state transition diagram.

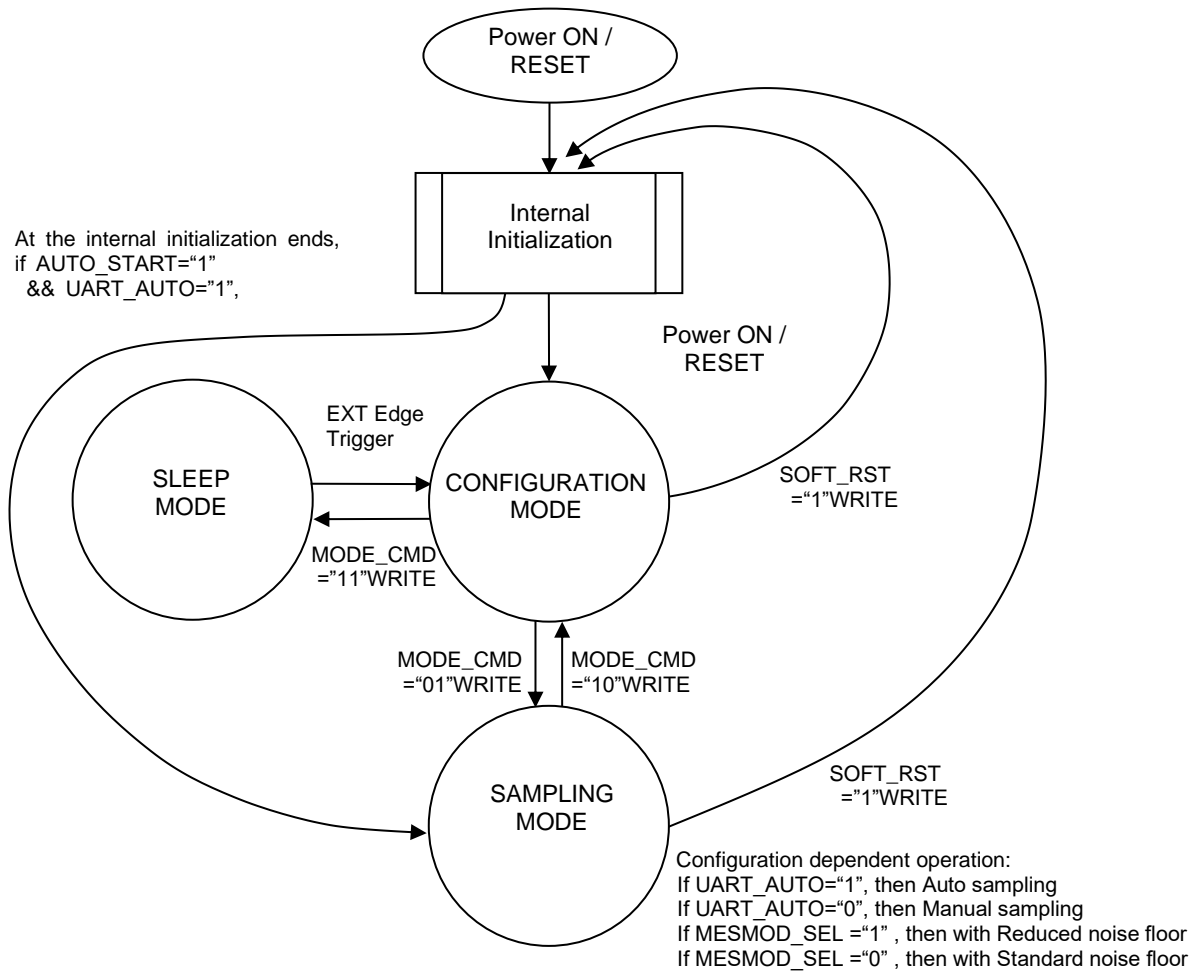


Figure 5-3 Operational State Diagram

5.6. Functional Block

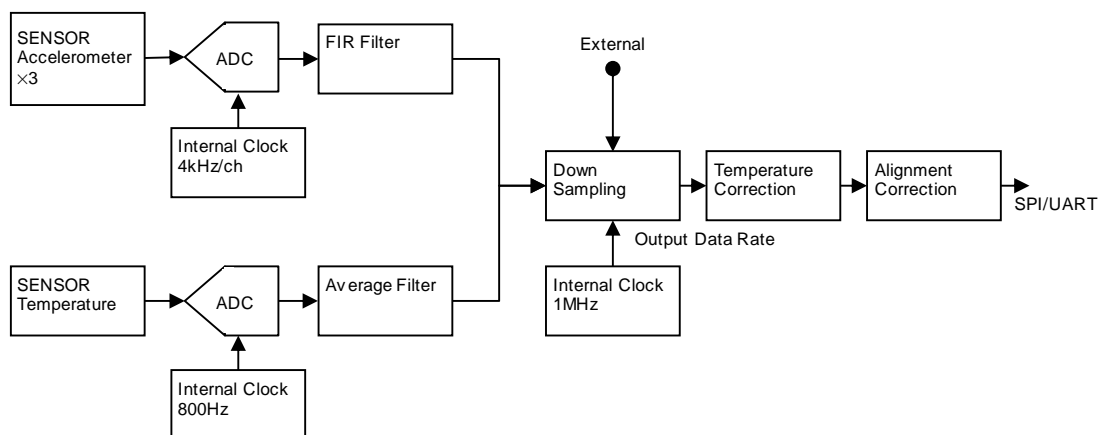


Figure 5-4 Functional Block Diagram

5.7. Sampling Counter

By reading COUNT[0x0A(W0)] register, the counter value, which is incremented based on the sampling completion timing of the internal A/D converter is returned. The count interval is 250usec/count and is based on the precision of the internal reference oscillator (crystal).

Additionally, during UART burst read or with UART Auto sampling, the counter value can be included in the response format by setting the **COUNT_OUT** (BURST_CTRL[0x0C(W1)] bit[1]). For information about the response format, see 6.3 DATA PACKET FORMAT.

5.8. Self Test

This product has the following self test functions. For information about the execution time of the self test, see "Self Test Time" in Table 2.4 Interface Specifications.

- Acceleration Value

This self test function can be used to check whether the outputs of the accelerometer are within the pre-determined range and operating properly.

The test result is OK if the absolute value of the output as a three dimensional vector is within the gravitational acceleration(0.8G to 1.2G).

When performing the self test, make sure the device does not move during the test and the test is conducted in a place without vibration.

To use this function, execute **ACC_TEST** of register: MSC_CTRL[0x02(W1)] bit[10], check the **ACC_ERR_ALL** of register DIAG_STAT[0x04(W0)] bit[1] for diagnostic result.

- Acceleration Sensitivity

This self test function can be used to determine whether the acceleration sensitivity error is within $\pm 2.5\%$. It takes up to 40 sec (typ.10 sec) per axis for the diagnostic.

To use this function, execute **SENS_TEST** of register: MSC_CTRL[0x02(W1)],bit[14:12], check the **SENS_ERR** of register DIAG_STAT[0x04(W0)],bit[11:10] for diagnostic result.

Note) It may lead to a diagnostic result of "unable to be determined" or may result in an inaccurate diagnostic when there are sudden changes in vibration level during the execution or the vibration level is lower than the noise floor of this product (refer to Section 4 Typical Performance Characteristics).

- Temperature Value

Determine whether the temperature sensor is operating properly.

To use this function, execute **TEMP_TEST** of register: MSC_CTRL [0x02 (W1)], bit [9], check the **TEMP_ERR** of register: DIAG_STAT [0x04 (W0)], bit [9] for diagnostic result.

- Power Supply Voltage Level

Determine whether the power supply voltage of the internal sensor is within 3.0V to 3.6V.

To use this function, execute **VDD_TEST** of register: MSC_CTRL[0x02(W1)],bit[8], check the **VDD_ERR** of register: DIAG_STAT[0x04(W0)],bit[8] for diagnostic result.

- Nonvolatile memory

Determine whether the Nonvolatile memory is operating properly by consistency test of data in nonvolatile memory.

To use this function, execute **FLASH_TEST** of register: MSC_CTRL[0x02(W1)],bit[11], check the **FLASH_ERR** of register: DIAG_STAT[0x04(W0)],bit[2] for diagnostic result.

5.9. Threshold Detection of Accelerometer

When the acceleration value exceeds the preset threshold, an alarm is indicated.

The threshold can be set for each 1G step within the range of 0 to 15 G upper limit and -15 G to 0 G lower limit. At the time of shipment, the upper limit + 15 G and the lower limit -15 G are set

The alarm threshold is set in the registers: XA_ALARM [0x47 - 0x46 (W1)], YA_ALARM [0x49 - 0x48 (W1)], ZA_ALARM [0x4B - 0x4A (W1)] and the alarm indication is registered in FLAG [0x06 (W0)], displayed in ***ALARM_ERR** of bit [4: 2]. Reading ***ALARM_ERR** will reset the alarm display.

5.10. Checksum

A checksum can be appended to the response data during a UART Burst read or UART Auto sampling by enabling this function in **CHKSM_OUT** (BURST_CTRL [0x0C(W1)] bit 0).

The range of the data content for checksum is after the address byte (AD=0x80) of the response data (Figure 5.10). The checksum is calculated with a simple addition of the data content in units of 16-bit, and the resulting sum is truncated to 16-bits and appended as checksum just before delimiter byte (CR=0x0D). For example:

Because the sum is "611B4" for the response data stream of "FE01 C455 4000 0052 33C0 0043 7BC8 004A 2608 FD73 3AA0 FF75 4C30 1F53 8FD0 0600 0014", the checksum is "11B4":

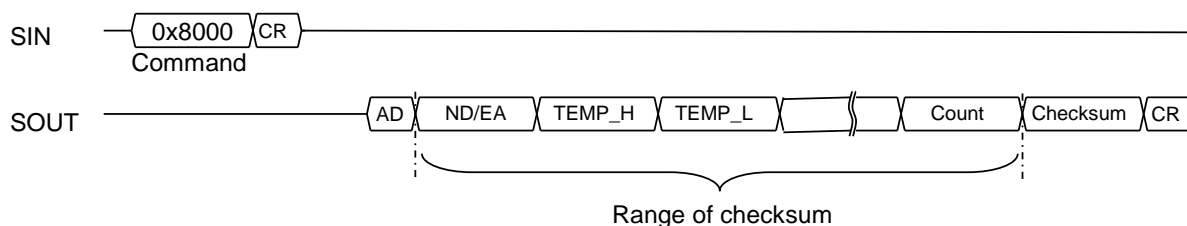


Figure 5-5 Checksum

5.11. Automatic Start (For UART Auto Sampling Only)

Automatic Start function is designed to be used in conjunction with the UART Auto sampling. When the power is supplied or the accelerometer is restart/reset, it allows the device to automatically enter Sampling mode after completing internal initialization. Please refer to Figure 5.3 for the state transition.

Follow the procedures below to enable the Automatic Start function:

- Write a "1" to both **UART_AUTO** (bit [0]) and **AUTO_START** (bit [1]) of **UART_CTRL** [0x08(W1)].
- Store the current register settings to non-volatile memory by writing a "1" to **FLASH_BACKUP** (**GLOB_CMD** [0x0A(W1)] bit [3]). After completion of the **FLASH_BACKUP** command, confirm the results by **FLASH_BU_ERR** (**DIAG_STAT** [0x04(W0)] bit [0]).
- The Accelerometer will automatically enter Sampling Mode after the power supply is cycled, or a hardware reset, or a software reset command is executed.

Follow the procedures below to disable this function.

- After entering sampling mode with automatic start, write "01" to **MODE_CMD** of register: **MODE_CTRL** [0x02 (W0)], bit [9: 8] and enter the configuration mode
- Write "0" to **AUTO_START** of register: **UART_CTRL** [0x08 (W1)], bit [1].
- The subsequent steps are the same as above. Please store the register setting to nonvolatile memory and restart or reset the accelerometer.

5.12. Bias Offset

This function adjusts acceleration bias of X, Y, Z axis. The user specified offset is applied to the measured acceleration value before being sent out the serial interface.

Set the bias offset value to the registers: **XA_OFFSET** [0x2F - 0x2C (W1)], **YA_OFFSET** [0x33 - 0x30 (W1)], **ZA_OFFSET** [0x37 - 0x34 (W1)]. The adjustment range is -15 G to +15 G. The data format is the same as the output format of register: **ACCL** [0x3A - 0x30 (W0)]. Both the X, Y, and Z axes are set to "0" when shipped.

5.13. Tilt Output / Combination Output

The device can be configured to output tilt angle by register setting. The tilt angle is calculated from the measured gravitational acceleration vector. The calculation formulas are as follows.

$$\theta = \text{asin}G[\text{rad}]$$

The device is configurable to select the measurement output type for each axis to be either acceleration or tilt angle. The measurement output type is selected with **OUTPUT_SEL_*** of register: **SIG_CTRL** [0x00 (W1)], bit [7: 5].

When both acceleration and tilt angle is outputting at the same time, set **OUTPUT_SEL** to "Tilt angle" and read register: ACCL [0x3A - 0x30 (W0)] and register: TILT [0x46 - 0x3C (W0)] in normal mode.

5.14. Measurement with Reduced Noise Floor Condition

The device can be configured to output data with a Reduced noise floor condition by register setting. Check the noise density characteristics shown in Figures 4.1-4.2 for standard noise floor level and reduced noise floor level.

Note) If the setting for the noise floor condition is switched from the standard condition to the reduced condition, current consumption during sampling increases.

Follow the procedures below to select a Reduced noise floor condition,

- Set **MESMOD_SEL** (SIG_CTRL[0x00(W1)], bit[4]) to "1: Enable".
- Store the current register settings to non-volatile memory by writing a "1" to **FLASH_BACKUP** (GLOB_CMD [0x0A(W1)], bit [3]). After completion of the **FLASH_BACKUP** command, confirm the results by **FLASH_BU_ERR** (DIAG_STAT [0x04(W0)], bit [0]) to be "0: No error".
- The Reduced noise floor condition will be applied after the power supply is cycled, or a hardware reset or a software reset command is executed. The status can be checked by **MESMOD_STAT** (GLOB_CMD[0x0A (W1)], bit[12]) to be "1: Reduced noise floor condition".
- Put the operation mode from configuration mode into sampling mode by writing "01" to **MODE_CMD** (MODE_CTRL[0x02(W0)], bit[9:8]) to start measurement with the Reduced noise floor condition.

Follow the procedures below to return to Standard noise floor .

- Set **MESMOD_SEL** (SIG_CTRL[0x00(W1)], bit[4]) to "0: Standard noise floor condition".
- The subsequent steps are the same as above. Please store the register setting to nonvolatile memory and restart or reset the device.

5.15. Bias Temperature Shock Compensation

The device is equipped with a bias stabilization function against thermal shock. The factory setting is set to "1: enable" for this function. When enabled, the time period for bias stabilization after power on is reduced, and the bias errors due to an environmental temperature change are reduced.

Note) This function when enabled may increase errors in estimation of inertial position when state estimation filters such as a Kalman filter are used for inertial navigation etc.

When data without bias temperature shock compensation is preferred, disable this function by setting **TEMP_STABIL** (SIG_CTRL[0x00(W1)], bit[2]) to "0: Disable".

5.16. FILTER

The device has a programmable internal FIR filter. The intermediate sensor signal at 4k sps is processed by the FIR filter and decimated according to the output timing and sent out the serial interface. The number of TAPs and a cutoff frequency can be set with the **FILTER_CTRL** [0x06(W1)] register.

5.16.1. FIR Kaiser Filter

Filter parameters correspond to the Kaiser window parameters.

The number of TAPs can be set to 64, 128, or 512, and the cutoff frequency F_c can be selected

according to the output sample rate. Figure 5-6 to Figure 5-9 show the typical characteristic of the filters.

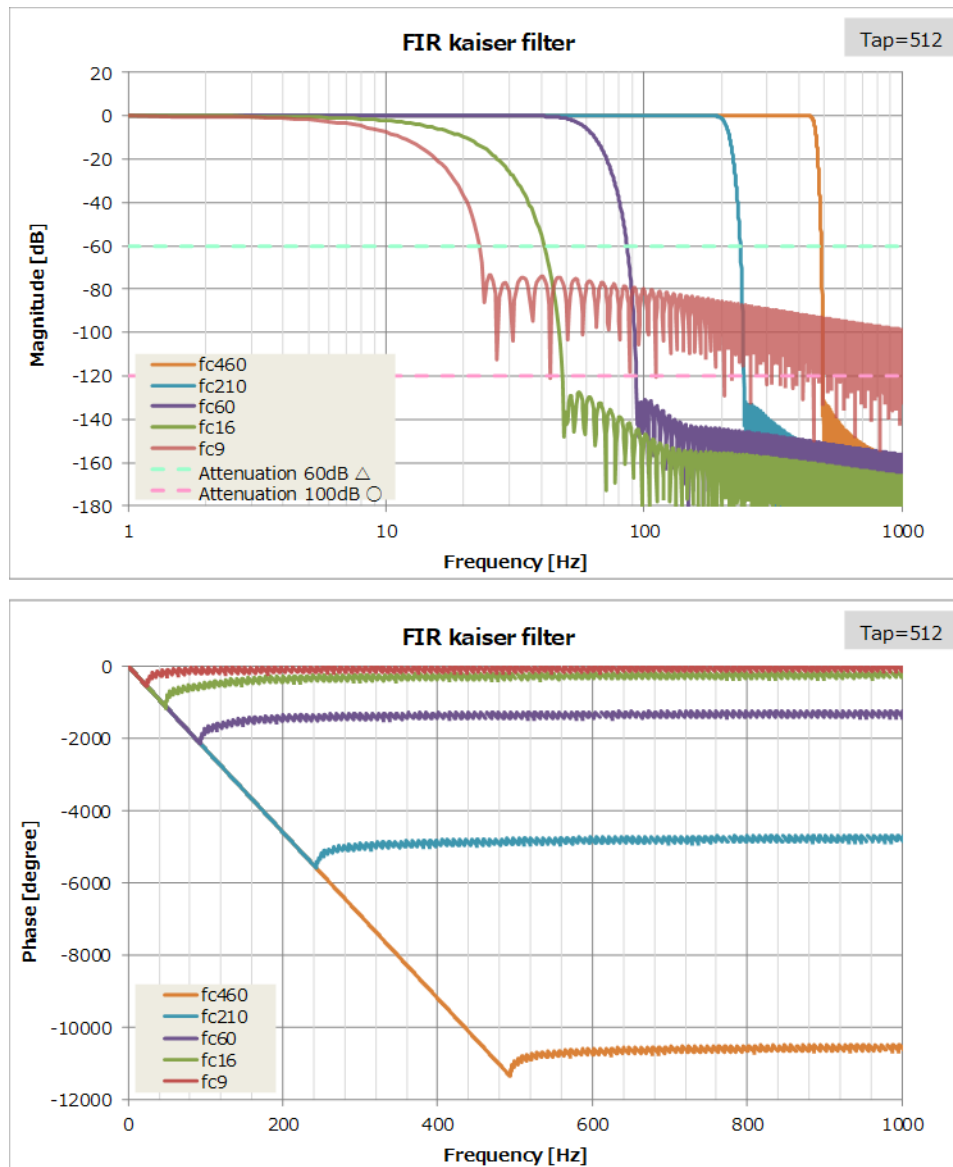


Figure 5-6 FIR Kaiser Characteristics—TAP512

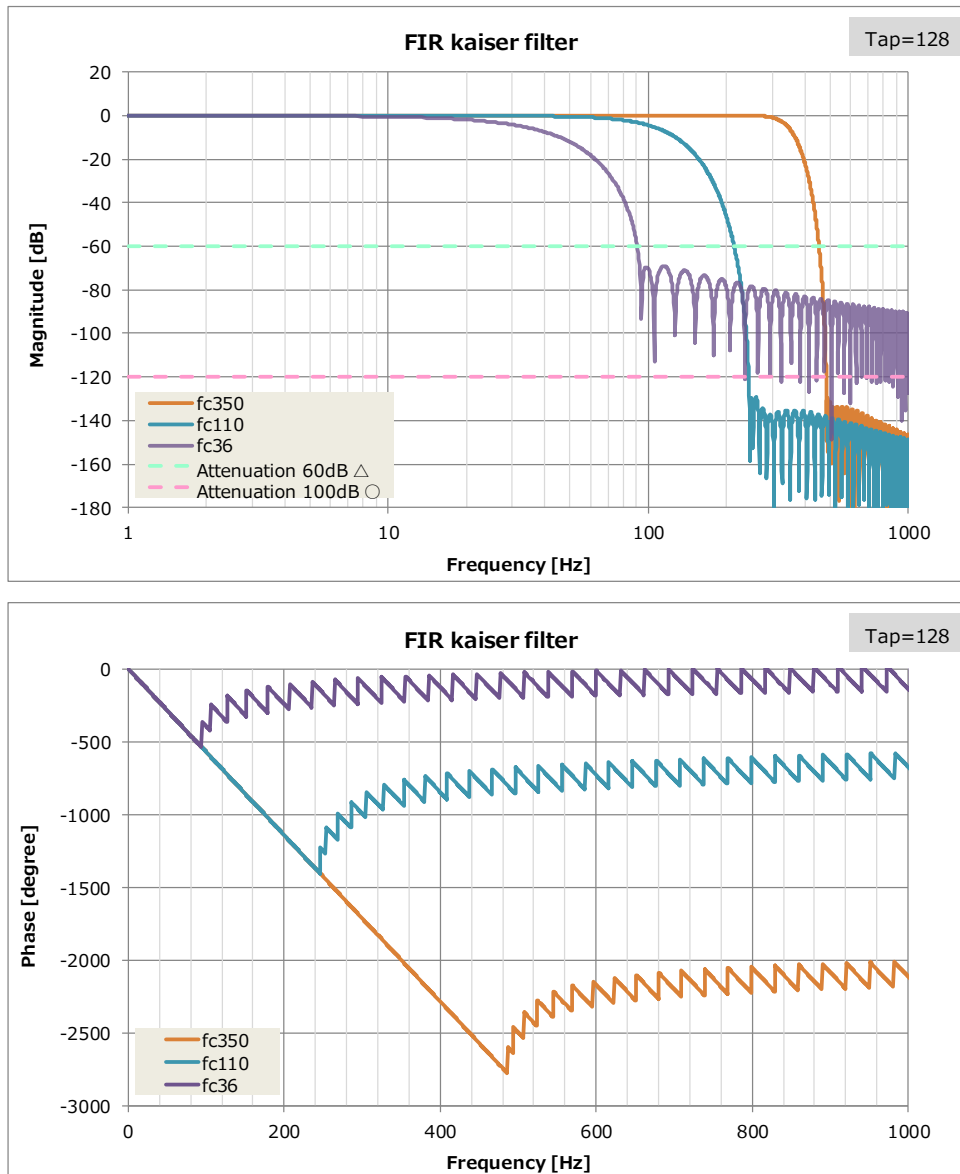


Figure 5-7 FIR Kaiser Characteristics—TAP128

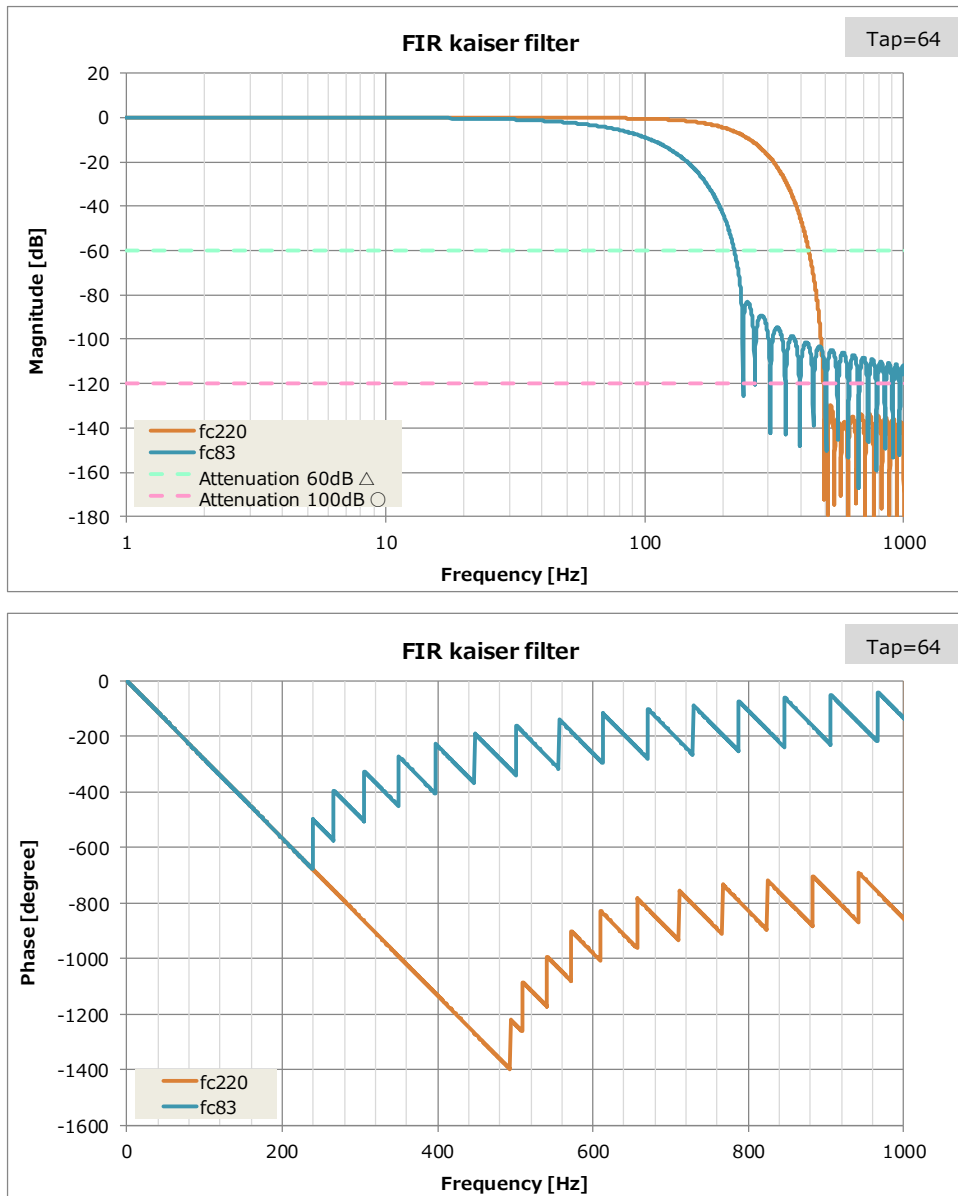


Figure 5-8 FIR Kaiser Characteristics – TAP64

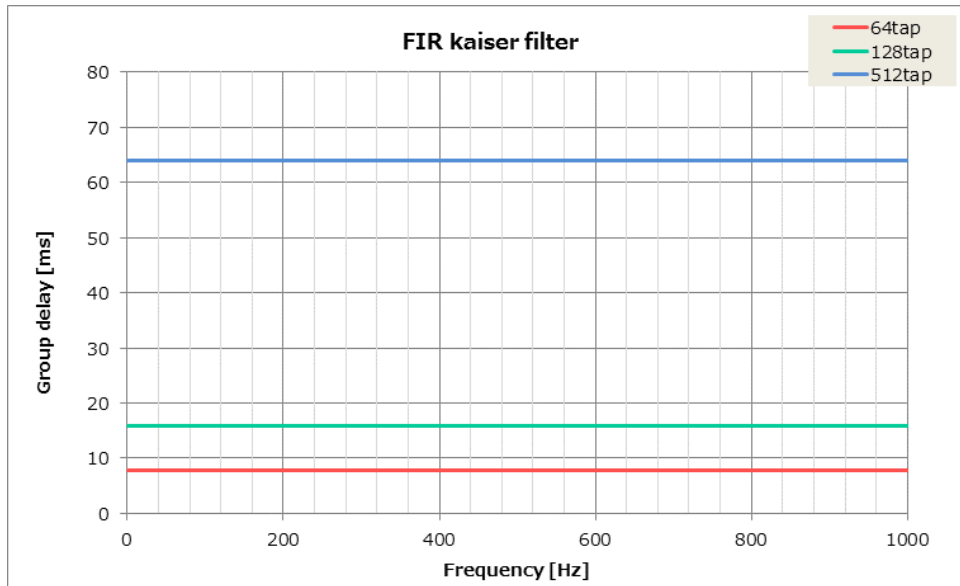


Figure 5-9 FIR Kaiser Characteristics – Group delay

5.16.2. User FIR Filter

The FIR filter can be arbitrarily defined by properly setting filter coefficients in the registers: FIR_UCMD [0x16 (W1)], FIR_UDATA [0x18 (W1)], FIR_UADDR [0x1A (W1)], and set **FILTER_SEL** of register: FILTER_CTRL [0x06(W1)] to "user defined FIR filter".

Follow the procedures below to program the user defined FIR filter.

- Register Programming Preparation

Set the filter coefficient value using signed 32 bit fixed point number with decimal point after bit [31]. For example, if the coefficient value in decimal form is 0.2195378928, the corresponding filter coefficient value in signed 32 bit fixed point form is $0.2195378928 * 2^{31} \cong 0x1C19D153$.

Table 5-1 shows the address ranges for the filter coefficients, and Figure 5-10 shows a N-tap FIR filter architecture and a coefficient memory map. The start address is common to each tap number and is at 0x0800. No specific values are set in memory at the time of factory shipment.

Table 5-1 User Defined FIR Filter Coefficient Address Ranges

Tap	Coefficient Address Range
4	0x0800-0x080F
64	0x0800-0x08FF
128	0x0800-0x09FF
512	0x0800-0x0FFF

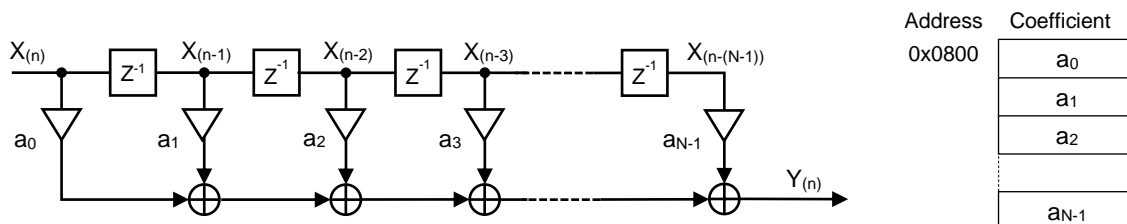


Figure 5-10 N-tap FIR Filter Architecture and Coefficient Memory Map

- Register Control (Write)

Set the filter coefficient address in register: FIR_UADDR [0x1B, 0x1A (W1)] and set the filter coefficient value in **FIR_UDATA** of register: FIR_UDATA [0x18 (W1)].

Set **FIR_UCMD** of register: FIR_UCMD [0x16 (W1)], bit [1: 0] to write the coefficient value. Next coefficient value can be set after waiting until the **FIR_UCMD** of register is to be "00: execution complete"

After the byte has completed writing, the address is automatically incremented by 1, so continuous programming of coefficients is possible without requiring additional address settings.

For the coefficient value, set the upper byte to the upper address and the lower byte to the lower address. Figure 5-11 shows the write sequence.

Please specify the type of filter, TAP setting and cutoff frequency using **FILTER_SEL** in register: FILTER_CTRL[0x06 (W1)], bit [3:0]. When selecting the user defined FIR filter, the **FILTER_SEL** register must reflect the filter coefficient data that are programmed in the device.

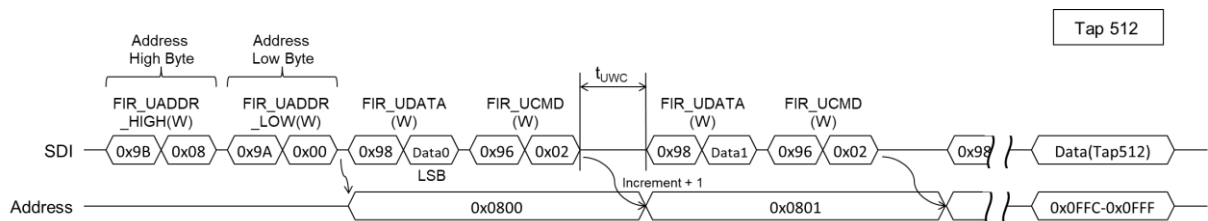


Figure 5-11 User Defined FIR Filter Coefficient Example Write Sequence (512 taps)

- Register Control (Read)

Set the filter coefficient address in register: FIR_UADDR [0x1B, 0x1A (W1)] and read the coefficient value using **FIR_UCMD** in register: FIR_UCMD [0x16 (W1)], bit [1: 0]. Next coefficient value can be read after waiting until the **FIR_UCMD** of register is to be "00: execution complete"

The address is automatically incremented by 1, so continuous execution of read commands is possible without requiring additional address settings. Figure 5-12 shows the read sequence.

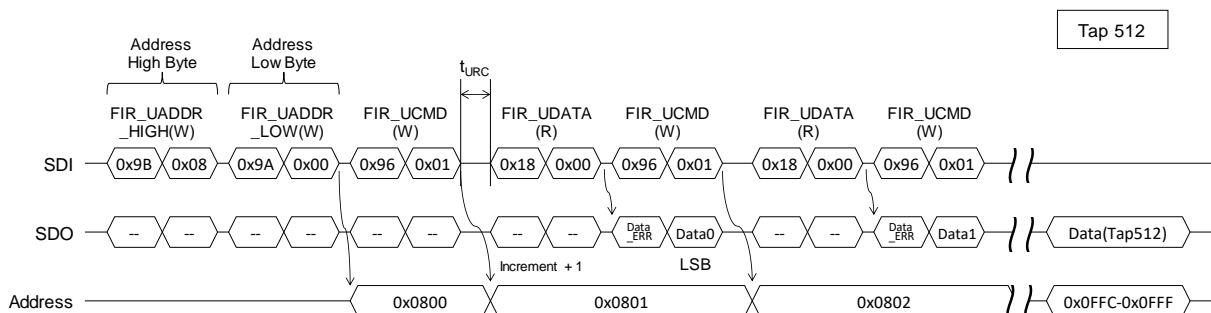


Figure 5-12 User Defined FIR Filter Coefficient Read Sequence (512 taps)

5.16.3. Notes For FIR Filter Usage

- Transient response

As shown in Table 5-2, transient response data is generated according to the combination of the tap number and the data output rate when sampling is started.

In the case of internal timer trigger measurement, the acceleration value of register ACCL [0x3A - 0x30(W0)] is not updated during this period.

In the case of automatic measurement, the device starts outputting data after the transient response.

Table 5-2 Transient Response Data Based on Output Data Rate and Filter Tap

	64 Taps	128 Taps	512 Taps
1,000sps	15	31	127
500sps	7	15	63
200sps		7	31
100sps			15
50sps			7

- Supported Settings For Output Rate and Filter Cutoff Frequency

The host must set the cutoff frequency of the FIR filter and the output rate in proper combination to avoid aliasing.

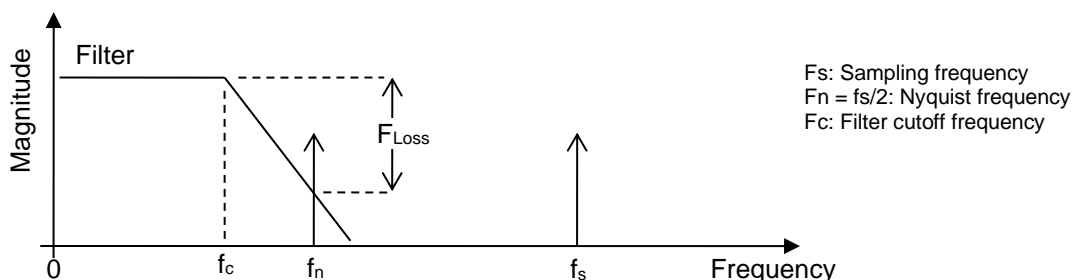


Figure 5-13 Anti-Aliasing Relationship Diagram

Table 5-3 Supported Settings for Output Rate and Filter Cutoff Frequency

				SMPL_CTRL Register (Internal Timer Trigger)				
	Tap	Fc	Group delay	Output Data Rate				
				50 Sps	100 Sps	200 Sps	500 Sps	1,000 Sps
FILTER_CTRL Register	512 Taps	460 Hz	63.875 ms	-	-	-	-	OK
		210 Hz		-	-	-	OK	OK
		60 Hz		-	-	OK*1	OK	OK
		16 Hz		-	OK	OK	OK	OK
		9 Hz		*	*	*	*	*
	128 Taps	350 Hz	15.875 ms	-	-	-	-	OK
		110 Hz		-	-	-	OK	OK
		36 Hz		-	-	*	*	*
	64 Taps	220 Hz	7.875 ms	-	-	-	-	OK

		83 Hz		-	-	-	*	*
--	--	-------	--	---	---	---	---	---

OK: $F_{Loss} < -120$ dB Recommended setting

- * : $F_{Loss} < -60$ dB Although a possible setting, some decrease in measurement quality due to aliasing
- : $F_n < F_c$ Invalid setting. When using internal timer measurement, measurement data returns with error "0x64000000".

Note) These settings are valid when the user defined FIR filter function is used or the external trigger input function is active,

*1) The factory setting is Tap: 512, F_c : 60 Hz, ODR: 200 Hz

5.16.4. Long-Term Filter (HPF, LPF)

In addition to the FIR filter, this product has a simple filter for long-term measurement. This filter consists of a moving average operating at the output data rate. The number of taps can be set to a power of 2 in the range 2 to 4096.

LPF is a two-stage configuration with the set number of taps.

HPF consists of a single-stage configuration with the set number of taps and subtracting the moving average from the original data.

When using a long-term filter, set **FILT_EN** of register: LONGFILT_CTRL [0x1C (W1)], bit [0] to "1: valid" and select "LPF" or "HPF" in bit [1] **FILT_SEL**.

Set the number of taps to TAP_SIZE of register: LONGFILT_TAP [0x1E (W1)].

Please note that transient response data is generated according to the combination of the tap size and a kind of filters (HPF/LPF) when sampling is started. Numbers of the transient response data for long period filters are shown in Table 5-4.

Table 5-4 Numbers of Transient Response Data for Long Period Filters

	Number of Transient Response Data
HPF	TAP Size
LPF	TAP Size * 2

Note) The maximum output rate is limited to 500 Sps when long-term filter is used.

6. HOST INTERFACE

6.1. SERIAL INTERFACE SPECIFICATION

6.1.1. COMMUNICATION CONDITION

Table 6-1 shows the supported UART communication settings and Figure 6-1 shows the UART bit format. Please refer to **BAUD_RATE** (UART_CTRL [0x08(W1)] bit[9:8]) for changing the baud rate setting.

Table 6-1 UART Communication Settings

Parameter	Settings
Transfer rate	115.2kbps/ 230.4kbps/ 460.8kbps
Start	1 bit
Data	8 bits
Stop	1 bit
Parity	None
Delimiter	CR(0x0D)

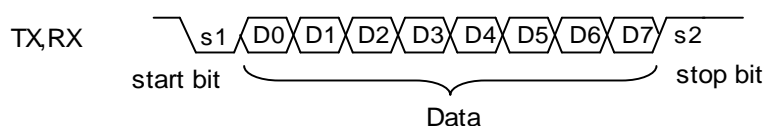


Figure 6-1 UART Bit Format

For the UART interface, a delimiter (1 byte) is placed at the end of each command (by the host) and response (by the IMU). In addition, for responses, the address (1 byte) specified by the command is added (by the IMU) to the beginning of the response.

Table 6-2 and Table 6-3 shows the timing of UART.

Table 6-2 UART Timing

Parameter	Manual Sampling				Auto Sampling		Unit
	Normal Mode		Burst Mode		Minimum	Maximum	
	Minimum	Maximum	Minimum	Maximum			
t _{STALL} (115.2kbps)	-	25	-	45	-	- *2	μs
t _{STALL} (230.4kbps)	-	25	-	45	-	- *2	μs
t _{STALL} (460.8kbps)	-	25	-	45	-	- *2	μs
t _{WRITERATE} (115.2kbps)	660	-	-	-	660	-	μs
t _{WRITERATE} (230.4kbps)	350	-	-	-	350	-	μs
t _{WRITERATE} (460.8kbps)	200	-	-	-	200	-	μs
t _{READRATE} (115.2kbps)	660	-	*1	-	- *2	-	μs
t _{READRATE} (230.4kbps)	350	-	*1	-	- *2	-	μs
t _{READRATE} (460.8kbps)	200	-	*1	-	- *2	-	μs

*1) Please refer to Table 6.9.

*2) Register reading is not supported while in Sampling Mode with UART Auto Sampling enabled.

Table 6-3 UART Timing (tREADRATE requirements for Burst Mode)

Parameter	Burst Mode (minimum)	Unit
tREADRATE(115.2kbps)	660 + 86.8 * B	μs
tREADRATE(230.4kbps)	350 + 43.4 * B	μs
tREADRATE(460.8kbps)	200 + 21.7 * B	μs

B= Number of receive data bytes (AD: address and CR: delimiter is not included).

Example tREADRATE Calculation:

BURST_CTRL[0x0C(W1)]: Set value 0x4702

B=18 byte for the above stated register setting

tREADRATE(460.8kbps) = 200 + (21.7 * 18) = 591(μs)

6.1.2. UART Read Timing (Normal Mode)

The response to the read command, i.e. the data from the internal register, is always returned 16-bit data at a time. The register address (AD) comes at the beginning of the response, for example, 0x02 for the MODE_CTRL [0x02(W0)] register.

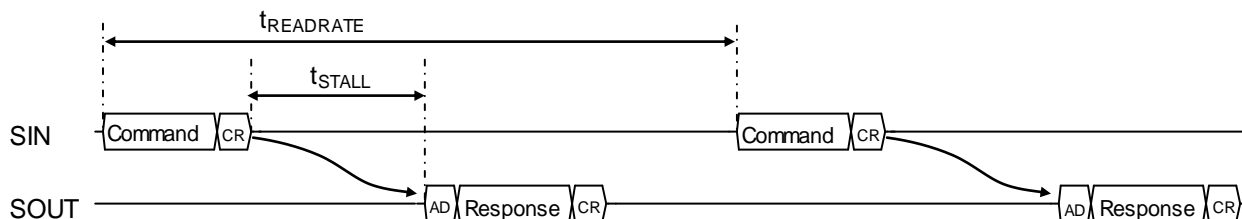


Figure 6-2 UART Read Timing (Normal Mode)

Table 6-4 Command Format (Read)

First byte								Second byte								Third byte							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
0	A[6:0]							XX								0x0D							

A[6:0] ... Register address (even address)

XX ... Don't Care

0x0D ... Delimiter

Table 6-5 Response Format (Read)

First byte								Second byte								Third byte								Fourth byte							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
0	A[6:0]							D[15:8]								D[7:0]								0x0D							

A[6:0] ... Register address (even address)

D[15:8] ... Register read data (upper byte)

D[7:0] ... Register read data (lower byte)

0x0D ... Delimiter

6.1.3. UART Read Timing (Burst Mode)

Burst mode access of read data is supported using a “Burst Read Command” by writing 0x00 in **BURST_CMD** (BURST [0x00(W0)] bits[7:0]). In Burst Mode, ND/EA flag, temperature sensor value, 3-axis acceleration sensor value, etc. are consecutively sent as a response. The response format for the burst read output data is configured by register setting in BURST_CTRL [0x0C(W1)]. Please refer to 6.2 Data Packet Format for the response format.

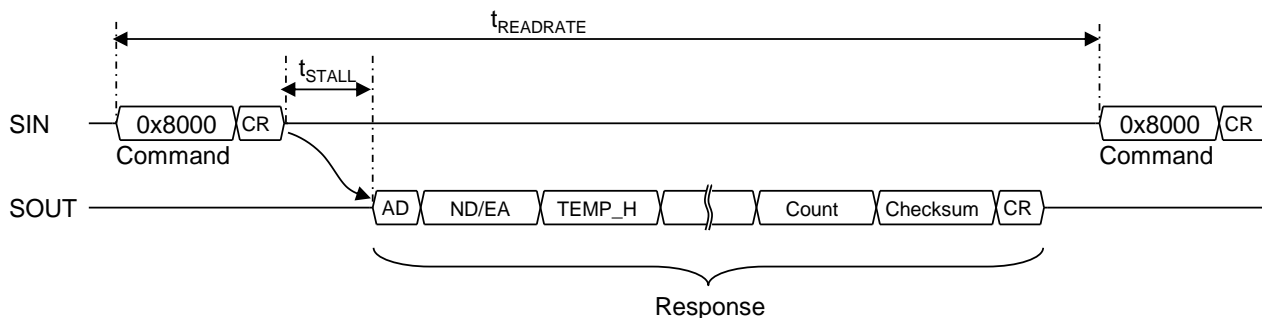


Figure 6-3 UART Read Timing (Burst Mode)

Table 6-6 Command Format (Burst Mode)

First byte								Second byte								Third byte							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
0x80								0x00								0x0D							

- 0x80 ... Burst Command
- 0x00 ... Burst Data 0x00
- 0x0D ... Delimiter

6.1.4. UART Write Timing

A write command to a register will have no response. Unlike register reading, registers are written in 8-bit words.

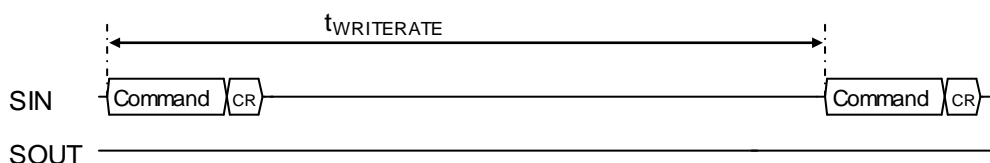


Figure 6-4 UART Write Timing

Table 6-7 Command Format (Write)

First byte								Second byte								Third byte							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
1	A[6:0]							D[7:0]								0x0D							

- A[6:0] ... Register address (even number or odd number)
- D[7:0] ... Register write data
- 0x0D ... Delimiter

6.1.5. UART Auto Sampling Operation

When UART Auto sampling is active, all sensor outputs are sent as burst transfer automatically at the programmed output data rate without the request from the Host. For information about the response format, see 6.2 UART Data Packet Format. The response format for the burst read output data is configured by register setting in BURST_CTRL [0x0C(W1)].

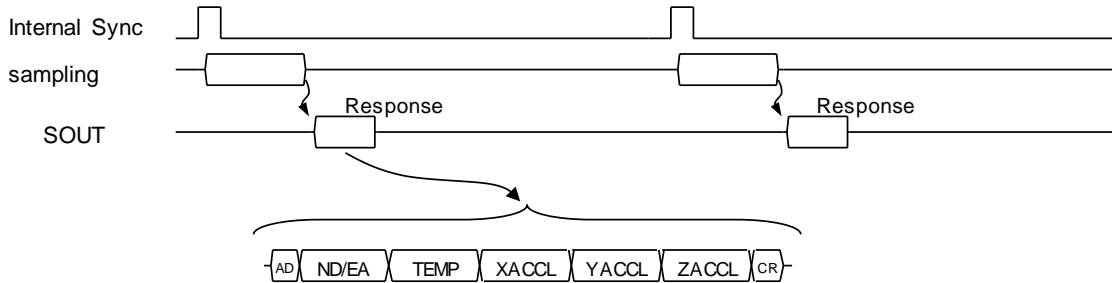


Figure 6-5 UART Auto Sampling Operation

6.2. Data Packet Format

The following table shows example of the data packet format sent to the host in the UART Burst Mode or UART Auto Sampling.

Table 6-8 UART Data Packet Format (UART Burst Mode / Auto Sampling) Example.
 BURST_CTRL[0x0C(W1)]=0xC703 (Burst Output, Temp, Acceleration, Counter, Checksum)
 SIG_CTRL[0x00(W1)]=0x8E04 (Output Mode: Acceleration, Bias stabilization: Enable)

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1	ADDRESS	0x80							
2	ND	ND (Temp)	-	-	-	ND (XACCL)	ND (YACCL)	ND (ZACCL)	-
3	EA	-	-	-	XALARM_ERR	YALARM_ERR	ZALARM_ERR	ALIASI_ERR	EA
4	TEMP_HIGH_H	TEMP_HIGH [15:8]							
5	TEMP_HIGH_L	TEMP_HIGH [7:0]							
6	TEMP_LOW_H	TEMP_LOW [15:8]							
7	TEMP_LOW_L	TEMP_LOW [7:0]							
8	XACCL_HIGH_H	XACCL_HIGH [15:8]							
9	XACCL_HIGH_L	XACCL_HIGH [7:0]							
10	XACCL_LOW_H	XACCL_LOW [15:8]							
11	XACCL_LOW_L	XACCL_LOW [7:0]							
12	YACCL_HIGH_H	YACCL_HIGH [15:8]							
13	YACCL_HIGH_L	YACCL_HIGH [7:0]							
14	YACCL_LOW_H	YACCL_LOW [15:8]							
15	YACCL_LOW_L	YACCL_LOW [7:0]							
16	ZACCL_HIGH_H	ZACCL_HIGH [15:8]							
17	ZACCL_HIGH_L	ZACCL_HIGH [7:0]							
18	ZACCL_LOW_H	ZACCL_LOW [15:8]							
19	ZACCL_LOW_L	ZACCL_LOW [7:0]							
20	COUNT_H	COUNT [15:8]							
21	COUNT_L	COUNT [7:0]							
22	CHECKSUM_H	CHECKSUM [15:8]							
23	CHECKSUM_L	CHECKSUM [7:0]							
24	CR	0x0D							

7. User Registers

A host device (for example, a microcontroller) can control the Accelerometer by accessing the control registers inside the device.

The registers are accessed in this device using a WINDOW method. The prescribed window number is first written to **WINDOW_ID** of WIN_CTRL[0x7E(W0/W1)] bit [7:0], then the desired register address can be accessed. The WIN_CTRL [0x7E(W0/W1)] register can always be accessed without needing to set the window number.

During the Power-On Start-Up Time or the Reset Recovery time specified in the Table 2-4 Interface Specifications, all the register values are undefined because internal initialization is in progress. Ensure the device registers are only accessed after the Power-On Start-Up Time or the Reset Recovery time is over.

For information about the initial values of the control registers after internal initialization is finished, see the “Default” column in the Table 7.1. The control registers with ◦ mark in the “Flash Backup” column can be saved to the non-volatile memory by the user, and the initial values after the power on will be the values read from the non-volatile memory. If the read out from the non-volatile memory fails, the **FLASH_ERR** (DIAG_STAT [0x04(W0)] bit[2]) is set to 1 (error).

Please ensure that the device is in the Configuration Mode before writing to registers. In the Sampling Mode, writing to registers is ignored **except** for the following cases.

- MODE_CTRL [0x02(W0)] bit [9:8] in **MODE_CMD**
- GLOB_CMD [0x0A(W1)] bit [7] in **SOFT_RST**
- WIN_CTRL [0x7E(W0/W1)] bit [7:0] in **WINDOW_ID**

While with the UART Auto sampling and Sampling Mode is active, register read access is not supported. Otherwise, the sampling data transmitted in the UART Auto sampling will be corrupted by the response data from the register read.

Each register is 16-bit wide and one address is assigned to every 8 bits. Registers are read in 16-bit words and are written in 8-bit words. The byte order of each 16-bit register is little endian, but the byte order of the 16-bit data transferred over the digital interface is big endian.

Table 7.1 shows the register map, and Section 7.1 through Section 7.30 describes the registers in detail.

The “-” sign in the register assignment table in Section 7.1 through Section 7.30 means “reserved”.

Write a “0” to reserved bits during a write operation.

During a read operation, a reserved bit can return either 0 or 1 (“don’t care”).

Writing to a read-only register is prohibited.

NOTE) The explanation of the register notation MODE_CTRL [0x02(W0)] bit [9:8] is as follows:

- MODE_CTRL: Register name
- [0x02(W0)]: First number is the Register Address, (W0) means Window Number “0”
- bit[9:8]: Bits 9 to 8

Table 7-1 Register Map

User Registers

Name	Window ID	Address	(*)Read Command 16bit Read	Write Command 8bitWrite	R/W	Flash Backup	Default	Function
BURST	0	0x00	-	0x80	W	-	-	Burst mode
		0x01		-	-		-	
MODE_CTRL	0	0x02	0x02XX	-	-	-	0x00	Operation mode control
		0x03		0x83	R/W		0x04	
DIAG_STAT	0	0x04	0x04XX	-	R	-	0x00	Diagnostic result
		0x05		-	R		0x00	
FLAG	0	0x06	0x06XX	-	R	-	0x00	ND/EA flag
		0x07		-	R		0x00	
COUNT	0	0x0A	0x0AXX	-	R	-	0x00	Sampling count
		0x0B		-	R		0x00	
TEMP_HIGH	0	0x0E	0x0EXX	-	R	-	0xFF	Temperature sensor value High
		0x0F		-	R		0xFF	
TEMP_LOW	0	0x10	0x10XX	-	R	-	0xFF	Temperature sensor value Low
		0x11		-	R		0xFF	
XACCL_HIGH	0	0x30	0x30XX	-	R	-	0xFF	X acceleration sensor value High
		0x31		-	R		0xFF	
XACCL_LOW	0	0x32	0x32XX	-	R	-	0xFF	X acceleration sensor value Low
		0x33		-	R		0xFF	
YACCL_HIGH	0	0x34	0x34XX	-	R	-	0xFF	Y acceleration sensor value High
		0x35		-	R		0xFF	
YACCL_LOW	0	0x36	0x36XX	-	R	-	0xFF	Y acceleration sensor value Low
		0x37		-	R		0xFF	
ZACCL_HIGH	0	0x38	0x38XX	-	R	-	0xFF	Z acceleration sensor value High
		0x39		-	R		0xFF	
ZACCL_LOW	0	0x3A	0x3AXX	-	R	-	0xFF	Z acceleration sensor value Low
		0x3B		-	R		0xFF	
XTILT_HIGH	0	0x3C	0x3CXX	-	R	-	0xFF	X Tilt sensor Value High
		0x3D		-	R		0xFF	
XTILT_LOW	0	0x3E	0x3EXX	-	R	-	0xFF	X Tilt sensor Value Low
		0x3F		-	R		0xFF	
YTILT_HIGH	0	0x40	0x40XX	-	R	-	0xFF	Y Tilt sensor Value High
		0x41		-	R		0xFF	
YTILT_LOW	0	0x42	0x42XX	-	R	-	0xFF	Y Tilt sensor Value Low
		0x43		-	R		0xFF	
ZTILT_HIGH	0	0x44	0x44XX	-	R	-	0xFF	Z Tilt sensor Value High
		0x45		-	R		0xFF	
ZTILT_LOW	0	0x46	0x46XX	-	R	-	0xFF	Z Tilt sensor Value Low
		0x47		-	R		0xFF	
SIG_CTRL	1	0x00	0x00XX	0x80	R/W	○	0x04	DataReady signal & polarity control
		0x01		0x81	R/W		0x8E	
MSC_CTRL	1	0x02	0x02XX	0x82	R/W	○	0x26	Other control
		0x03		0x83	R/W		0x00	
SMPL_CTRL	1	0x04	0x04XX	-	-	○	0x00	Sampling control
		0x05		0x85	R/W		0x04	
FILTER_CTRL	1	0x06	0x06XX	0x86	R/W	○	0x08	Filter control
		0x07		-	-		0x00	
UART_CTRL	1	0x08	0x08XX	0x88	R/W	○	0x00	UART control
		0x09		0x89	R/W		0x02	
GLOB_CMD	1	0x0A	0x0AXX	0x8A	R/W	-	0x00	System control
		0x0B		-	R		0x00	
BURST_CTRL	1	0x0C	0x0CXX	0x8C	R/W	○	0x02	Burst control
		0x0D		0x8D	R/W		0x47	
FIR_UCMD	1	0x16	0x16XX	0x96	R/W	-	0x00	User FIR Filter control
		0x17		-	-		0x00	
FIR_UDATA	1	0x18	0x18XX	0x98	R/W	-	0x00	User FIR Filter coefficient data
		0x19		-	R		0x00	
FIR_UADDR	1	0x1A	0x1AXX	0x9A	R/W	-	0x00	User FIR Filter coefficient Address
		0x1B		0x9B	R/W		0x08	

LONGFILT_CTRL	1	0x1C	0x1CXX	0x9C	R/W	○	0x00	Long period filter control
		0x1D		-	-		0x00	
LONGFILT_TAP	1	0x1E	0x1EXX	0x9E	R/W	○	0x0A	Long period filter tap number
		0x1F		-	-		0x00	
OFFSET_XA_HIGH	1	0x2C	0x2CXX	0xAC	R/W	○	0x00	X acceleration offset value High
		0x2D		0xAD	R/W		0x00	
OFFSET_XA_LOW	1	0x2E	0x2EXX	0xAE	R/W	○	0x00	X acceleration offset value Low
		0x2F		0xAF	R/W		0x00	
OFFSET_YA_HIGH	1	0x30	0x30XX	0xB0	R/W	○	0x00	Y acceleration offset value High
		0x31		0xB1	R/W		0x00	
OFFSET_YA_LOW	1	0x32	0x32XX	0xB2	R/W	○	0x00	Y acceleration offset value Low
		0x33		0xB3	R/W		0x00	
OFFSET_ZA_HIGH	1	0x34	0x34XX	0xB4	R/W	○	0x00	Z acceleration offset value High
		0x35		0xB5	R/W		0x00	
OFFSET_ZA_LOW	1	0x36	0x36XX	0xB6	R/W	○	0x00	Z acceleration offset value Low
		0x37		0xB7	R/W		0x00	
XALARM	1	0x46	0x46XX	0xC6	R/W	○	0xF1	X acceleration alarm
		0x47		0xC7	R/W		0x0F	
YALARM	1	0x48	0x48XX	0xC8	R/W	○	0xF1	Y acceleration alarm
		0x49		0xC9	R/W		0x0F	
ZALARM	1	0x4A	0x4AXX	0xCA	R/W	○	0xF1	Z acceleration alarm
		0x4B		0xCB	R/W		0x0F	
PROD_ID1	1	0x6A	0x6AXX	-	R	-	0x41	Product ID 1
		0x6B		-	R		0x33	
PROD_ID2	1	0x6C	0x6CXX	-	R	-	0x35	Product ID 2
		0x6D		-	R		0x32	
PROD_ID3	1	0x6E	0x6EXX	-	R	-	0x41	Product ID 3
		0x6F		-	R		0x44	
PROD_ID4	1	0x70	0x70XX	-	R	-	0x31	Product ID 4
		0x71		-	R		0x30	
VERSION	1	0x72	0x72XX	-	R	-	(*)	Firmware version
		0x73		-	R			
SERIAL_NUM1	1	0x74	0x74XX	-	R	-	(*)	Serial Number 1
		0x75		-	R			
SERIAL_NUM2	1	0x76	0x76XX	-	R	-	(*)	Serial Number 2
		0x77		-	R			
SERIAL_NUM3	1	0x78	0x78XX	-	R	-	(*)	Serial Number 3
		0x79		-	R			
SERIAL_NUM4	1	0x7A	0x7AXX	-	R	-	(*)	Serial Number 4
		0x7B		-	R			
WIN_CTRL	0,1	0x7E	0x7EXX	0xFE	R/W	-	0x00	Register Window Control
		0x7F		-	-		0x00	

*1. It depends on the version of the installed firmware.

*2. It is determined by each individual serial number.

*3. Lower byte XX: Do not care

7.1. BURST Register (Window 0)

Addr (Hex)	Bit15	...	Bit8	R/W
------------	-------	-----	------	-----

0x01	-	-
------	---	---

Addr (Hex)	Bit7	...	Bit0	R/W
0x00	BURST_CMD			W

bit[7:0] BURST_CMD

A burst mode read operation is initiated by writing 0x00 in **BURST_CMD** of this register.

NOTE) The data transmission format is described in 6.1.3 SPI Read Timing (Burst Mode) and 6.2.2 UART Read Timing (Burst Mode). Also refer to 6.3 Data Packet Format. The output data can be selected by setting BURST_CTRL [0x0C(W1)].

7.2. MODE_CTRL Register (Window 0)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x03	-	-	-	-	MODE_STAT		MODE_CMD		R/W *1

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x02	-	-	-	-	-	-	-	-	-

*1) MODE_STAT is read-only.

bit[11:10] MODE_STAT

This read-only status bit shows the current operation mode.

- 00: Sampling Mode
- 01: Configuration mode
- 10: Sleep Mode
- 11: (Not Used)

bit[9:8] MODE_CMD

Executes commands related to the operation mode.

- 00: Execute Complete.
- 01: Go to the Sampling Mode.
After the mode transition is completed, the bits automatically goes back to "00".
- 10: Go to the Configuration Mode.
After the mode transition is completed, the bits automatically goes back to "00".
- 11: Go to the Sleep Mode.
After the mode transition is completed, the bits automatically goes back to "00".

7.3. DIAG_STAT Register (Window 0)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x05	ACC_VS_ERR	ACC_X_ERR	ACC_Y_ERR	ACC_Z_ERR	SENS_ERR		TEMP_ERR	VDD_ERR	R

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x04	HARD _ERR			-	UART _OVF	FLASH _ERR	ACC_ERR _ALL	FLASH_ BU_ERR	R

Note) When the host reads the diagnosis result, all the results (including the EA flag in the FLAG register) will be cleared to 0.

bit[15] ACC_VES_ERR (ACC VECtorSynthesis ERRor)

Shows the execution result of vector composite value of acceleration three axes in **ACC_TEST** of MSC_CTRL [0x02 (W1)], bit [10].

- 1: Error occurred
- 0: No error

If this error occurs, acceleration sensor is faulty.

bit[14] ACC_X_ERR

Shows the result of X axis acceleration sensor operation check in **ACC_TEST** of MSC_CTRL [0x02 (W1)], bit [10].

- 1: Error occurred
- 0: No error

If this error occurs, X axis acceleration sensor has failed (operation stop)

bit[13] ACC_Y_ERR

Shows the result of Y axis acceleration sensor operation check in **ACC_TEST** of MSC_CTRL [0x02 (W1)], bit [10].

- 1: Error occurred
- 0: No error

If this error occurs, Y axis acceleration sensor has failed (operation stop)

bit[12] ACC_Z_ERR

Shows the result of Z axis acceleration sensor operation check in **ACC_TEST** of MSC_CTRL [0x02 (W1)], bit [10].

- 1: Error occurred
- 0: No error

If this error occurs, Z axis acceleration sensor has failed (operation stop)

bit[11:10] SENS_ERR (SENSitivity ERRor)

Shows the execution result of **SENS_TEST** (Sensitivity Test) of MSC_CTRL [0x02 (W1)], bit [14:12].

- 11 : Not used
- 10 : Unable to be determined
- 01 : Error occurred
- 00 : No error

If this error occurs, acceleration sensor is faulty.

bit[9] TEMP_ERR

Shows the execution result of **TEMP_TEST** (Temp Sensor Check) of MSC_CTRL [0x02 (W1)], bit [9].

- 1: Error occurred
- 0: No error

If this error occurs, temperature sensor is faulty.

bit[8] VDD_ERR

Shows the execution result of **VDD_TEST** (Power Supply Voltage Check) of MSC_CTRL [0x02 (W1)], bit [8].

- 1: Error occurred
- 0: No error

If this error occurs, Check whether the power supply voltage level is within the specified range.

bit[7:5] HARD_ERR

Shows the result of the hardware check at startup.

Other than 000: Error occurred

000 : No error

When this error occurs, it indicates the device is faulty.

bit[3] UART_OVF (UART OVer Flow)

Shows an error occurred if the data transmission rate is faster than the UART baud rate.

1: Error occurred

0: No error

When this error occurs, review the settings for the baud rate (register: UART_CTRL[0x08(W1)], bit[9:8]), data output rate (register: SMPL_CTRL[0x04(W1)], bit[11:8]), UART Burst Mode / Auto sampling (register: BURST_CTRL[0x0C(W1)]) in combination.

bit[2] FLASH_ERR

Shows the result of **FLASH_TEST** of MSC_CTRL [0x02(W1)] bit[11].

1: Error occurred

0: No error

This error indicates a failure occurred when reading data out from the non-volatile memory.

bit[1] ACC_ERR_ALL (ACCTest ERRor All)

Shows the logical sum of bit [15:12] of this register.

1: Error occurred

0: No error

bit[0] FLASH_BU_ERR (FLASH BackUp ERRor)

Shows the result of **FLASH_BACKUP** of GLOB_CMD [0x0A(W1)] bit [3].

1: Error occurred

0: No error

7.4. FLAG(ND/EA) Register (Window 0)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x07	ND (Temp)	-	-	-	ND (XACCL)	ND (YACCL)	ND (ZACCL)	-	R

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x06	-	-	-	XALARM_ERR	YALARM_ERR	ZALARM_ERR	ALIASI_ERR	EA	R

Note) ALARM_ERR flags are cleared to "0" by reading this register.

Note) The EA flag is cleared to "0" by reading the DIAG_STAT register.

Note) The ALIASI_ERR flag is updated when writing to the SMPL_CTRL or FILTER_CTRL register.

bit[15] ND(New Data) flag (Temperature)

When new measurement data is set in temperature register: TEMP_HIGH [0x0E (W0)], this bit is set to "1". This bit is reset to "0" reading by the temperature register.

bit[11:9] ND(New Data) flag (Acceleration)

When new measurement data is set in acceleration register: XACCL_HIGH[0x30(W0)], YACCL_HIGH[0x34(W0)], ZACCL_HIGH[0x38(W0)], this bit is set to "1". This bit is reset to "0" by reading the temperature register.

bit[4] XALARM_ERR(XAcc_ALARM_ERROR)

This bit indicates when the acceleration exceeds the value set in register: XA_ALARM[0x47-0x46(W1)] in the X axis during measurement.

1: detection

0: no detection

bit[3] YALARM_ERR(YAcc_ALARM_ERrOr)

This bit indicates when the acceleration exceeds the value set in register: YA_ALARM[0x49-0x48(W1)] in the Y axis during measurement.

- 1: detection
- 0: no detection

bit[2] ZALARM_ERR(ZAcc_ALARM_ERrOr)

This bit indicates when the acceleration exceeds the value set in register: ZA_ALARM[0x4B-0x4A(W1)] in the Z axis during measurement.

- 1: detection
- 0: no detection

bit[1] ALIASI_ERR(ALIASIng_ERrOr)

This bit indicates the validation check of the combination setting of the output rate in register: SMPL_CTRL[0x04(W1)],bit[11:8] and filter cutoff frequency in register: FILTER_CTRL[0x06(W1)],bit[3:0].

- 1: Abnormal Setting
- 0: Normal Setting

bit[0] EA(All Error) flag

When at least one failure is found in the diagnostic result (DIAG_STAT [0x04(W0)]), this bit is set to "1"(failure occurred). This bit is reset to "0" by reading the DIAG_STAT register.

- 1: Failure occurred
- 0: No Failure

7.5. COUNT Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x0A	COUNT			R

bit[15:0] COUNT

This register returns the sampling count value of the internal A/D converter.

Note) The time unit of the sampling counter value represents 250 μs/count.

Example: If the data output rate equals 1000Sps, the counter value sequence is 4,8,12, ... , 0xFFFC, 0, 4,

7.6. TEMP Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x0E	TEMP_HIGH			R
0x10	TEMP_LOW			R

bit[15:0] Temperature sensor output data

The internal temperature sensor value can be read from this register.
The output data format is 32-bit two's complement format.

Please refer to the below formula for conversion to temperature in centigrade. Please refer to Table 2.3 Sensor Specification for the scale factor value.

The reference value in this register is for the temperature correction. There is no guarantee that the value provides the absolute value of the internal temperature.

$$T [^{\circ}\text{C}] = \text{SF} * a + 34.987$$

SF: Scale Factor

A: Temperature sensor output data (decimal)

7.7. ACCL Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x30	XACCL_HIGH			R
0x32	XACCL_LOW			R
0x34	YACCL_HIGH			R
0x36	YACCL_LOW			R
0x38	ZACCL_HIGH			R
0x3A	ZACCL_LOW			R

bit[15:0] Acceleration sensor output data

These registers contain the 3-axis acceleration data for X, Y, and Z.

Register: SIG_CTRL [0x00 (W1)] provides the output mode selection OUTPUT_SEL of bit [7: 5] to specify the acceleration data as either "acceleration" or "Tilt angle".

The output data format

Unit [G]

32-bit two's complement format

bit31 : sign

bit30~24 : integer

bit23~0 : decimal

Note) When the combination of output rate and filter cutoff frequency is "abnormal setting", reading acceleration sensor value responds with error code "0x64000000"

Note) When the acceleration value exceeds the preset threshold value, reading acceleration value responds with the threshold value. For example, if the preset threshold values are set to +15 G and -15 G, the corresponding response is "0x0F000000" for +15 G or more, and "0xF1000000" for -15 G or less.

7.8. TILT Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x3C		XTILT_HIGH		R
0x3E		XTILT_LOW		R
0x40		YTILT_HIGH		R
0x42		YTILT_LOW		R
0x44		ZTILT_HIGH		R
0x46		ZTILT_LOW		R

bit[15:0] Tilt sensor output data

These registers contain the 3-axis Tilt angle data for X, Y, and Z.

Register: SIG_CTRL [0x00 (W1)] The tilt angle is output only when the output mode selection OUTPUT_SEL of bit [7: 5] is set to "tilt angle".

The output data format

Unit [radian]

32-bit two's complement format

bit31 : sign

bit30~29 : integer

bit28~0 : decimal

Note) When the combination of output rate and filter cutoff frequency is "abnormal setting", reading tilt angle sensor value responds with error code "0x64000000"

Note) When the tilt angle value exceeds the dynamic range (± 60 deg), reading tilt angle value responds with the value of +60 deg or -60 deg. For example, the corresponding response is "0x2182A470" for +60 deg or more, and "0xDE7D5B90" for -60 deg or less.

7.9. SIG_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x01	ND_EN (Temp)	-	-	-	ND_EN (XACCL)	ND_EN (YACCL)	ND_EN (ZACCL)	-	R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x00	OUTPUT_SEL_X	OUTPUT_SEL_Y	OUTPUT_SEL_Z	MESMOD_SEL	-	TEMP_STABIL	-	-	R/W

bit[15] ND_EN (Temp)

Enables or disables the temperature sensor ND flags in FLAG [0x06(W0)] bit [15].

1: Enable

0: Disable

bit[11] ND_EN (X Acceleration sensor)

Enables or disables the X Acceleration sensor ND flags in FLAG [0x06(W0)] bit [11].

1: Enable

0: Disable

bit[10] ND_EN (Y Acceleration sensor)

Enables or disables the Y Acceleration sensor ND flags in FLAG [0x06(W0)] bit [10].

1: Enable

0: Disable

bit[9] ND_EN (Z Acceleration sensor)

Enables or disables the Z Acceleration sensor ND flags in FLAG [0x06(W0)] bit [9].

1: Enable

0: Disable

bit[7] OUTPUT_SEL_X

Sets the output mode on the X axis.

1: Tilt angle

0: Acceleration

bit[6] OUTPUT_SEL_Y

Sets the output mode on the Y axis.

1: Tilt angle

0: Acceleration

bit[5] OUTPUT_SEL_Z

Sets the output mode on the Z axis.

1: Tilt angle

0: Acceleration

bit[4] MESMOD_SEL

Sets the measurement condition.

1: Reduced noise floor condition

0: Standard noise floor condition

When **MESMOD_SEL** is set, the device can operate with the set measurement condition after completing internal initialization after powered on or a reset.

Write to this **MESMOD_SEL** bit. Then execute FLASH_BACKUP of GLOB_CMD [0x0A(W1)] bit [3] to preserve the current register settings. Read the **MESMOD_STAT** of register:

GLOB_CMD[0x0A (W1)],bit[12] to check the current setting of measurement condition.

bit[2] TEMP_STABIL

Bias stabilization against thermal shock.

1: Enable

0: Disable

7.10. MSC_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x03	-	Z_SENS_TEST	Y_SENS_TEST	X_SENS_TEST	FLASH_TEST	ACC_TEST	TEMP_TEST	VDD_TEST	R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x02	-	0	-	-	-	-	-	-	R/W

Note) Although ACC_TEST, TEMP_TEST, and VDD_TEST can be executed at the same time, other tests cannot be executed at the same time.

When executing them in succession, confirm the execution of the previous command is finished by waiting until the bit changes from "1" to "0" and then execute the next command.

bit[14] Z_SENS_TEST

Write “1” to execute the self test to check if the Z axis accelerometer sensitivity is working properly. The read value of the bit is “1” during the test and “0” after the test is completed. After writing “1” to this bit, wait until this bit goes back to “0” and then read the **SENS_ERR** of **DIAG_STAT [0x04(W0)]** bit [11:10] to check the result.

bit[13] Y_SENS_TEST

Write “1” to execute the self test to check if the Y axis accelerometer sensitivity is working properly. The read value of the bit is “1” during the test and “0” after the test is completed. After writing “1” to this bit, wait until this bit goes back to “0” and then read the **SENS_ERR** of **DIAG_STAT [0x04(W0)]** bit [11:10] to check the result.

bit[12] X_SENS_TEST

Write “1” to execute the self test to check if the X axis accelerometer sensitivity is working properly. The read value of the bit is “1” during the test and “0” after the test is completed. After writing “1” to this bit, wait until this bit goes back to “0” and then read the **SENS_ERR** of **DIAG_STAT [0x04(W0)]** bit [11:10] to check the result.

bit[11] FLASH_TEST

Write “1” to execute the data consistency test for the non-volatile memory. The read value of the bit is “1” during the test and “0” after the test is completed. After writing “1” to this bit, wait until this bit goes back to “0” and then read the **FLASH_ERR** of **DIAG_STAT [0x04(W0)]** bit [2] to check the result.

bit[10] ACC_TEST

Write “1” to execute the self test to check if the accelerometer is working properly. The read value of the bit is “1” during the test and “0” after the test is completed. After writing “1” to this bit, wait until this bit goes back to “0” and then read the **ACC_ERR_ALL** of **DIAG_STAT [0x04(W0)]** bit [1] to check the results.

bit[9] TEMP_TEST

Write “1” to execute the self test to check if temperature sensor is working properly. The read value of the bit is “1” during the test and “0” after the test is completed. After writing “1” to this bit, wait until this bit goes back to “0” and then read the **TEMP_ERR** of **DIAG_STAT [0x04(W0)]** bit [9] to check the results.

bit[8] VDD_TEST

Write “1” to execute the self test to check if power supply voltage level is working properly. The read value of the bit is “1” during the test and “0” after the test is completed. After writing “1” to this bit, wait until this bit goes back to “0” and then read the **VDD_ERR** of **DIAG_STAT [0x04(W0)]** bit [8] to check the results.

bit[6] Fixed to 0

This function cannot be used. Fix to 0.

7.11. SMPL_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x05	-	-	-	-	DOUT_RATE				R/W

Addr (Hex)	Bit7	...	Bit0	R/W
0x04	-			-

bit[11:8] DOUT_RATE

Specifies the data output rate. To avoid aliasing, refer to Table 5.4 Measurable output rate and cutoff frequency combination for output rate setting.

0000: Reserved

0001: Reserved

0010: 1,000Sps

0011: 500Sps

0100: 200Sps

0101: 100Sps

0110: 50Sps

0111-1111: not used

*1) The factory setting is ODR: 200 Hz

Note) The maximum output rate is limited to 500 Sps when long-term filter is used.

7.12. FILTER_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x07	-	-	-	-	-	-	-	-	-

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x06	-	-	FILTER_STAT	-	FILTER_SEL				R/W *1

*1) Only FILTER_STAT is read-only.

bit[5] FILTER_STAT

This read-only status bit shows the status of the filter setting

1: Filter setting is busy

0: Filter setting is completed

bit[3:0] FILTER_SEL

Specifies the type of filter, TAP setting and cutoff frequency.

For the FIR Kaiser filter, these bits also selects the cutoff frequency. When using user defined FIR filter, please program the filter coefficient data

0000: Reserved

0001: FIR Kaiser Filter TAP=64, fc=83

0010: FIR Kaiser Filter TAP=64, fc=220

0011: FIR Kaiser Filter TAP=128, fc=36

0100: FIR Kaiser Filter TAP=128, fc=110

0101: FIR Kaiser Filter TAP=128, fc=350

0110: FIR Kaiser Filter TAP=512, fc=9

0111: FIR Kaiser Filter TAP=512, fc=16

1000: FIR Kaiser Filter TAP=512, fc=60

1001: FIR Kaiser Filter TAP=512, fc=210

1010: FIR Kaiser Filter TAP=512, fc=460

1011: User Defined FIR Filter TAP=4

1100: User Defined FIR Filter TAP=64

1101: User Defined FIR Filter TAP=128

1110: User Defined FIR Filter TAP=512

1111: not used

After writing to this bit, FILTER_STAT changes to 1 (during execution).

Confirm the completion of the filter setting process by confirming that the FILTER_STAT bit returns to "0".

Note) For the combination of output rate and cutoff frequency considering avoidance of aliasing and transient response at sampling start, refer to 5.17.3 Notes on FIR filter.

Note) The factory settings are Tap: 512, Fc: 60 Hz

7.13. UART_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x09	-						BAUD_RATE		R/W

Addr (Hex)	Bit7	...	Bit2	Bit1	Bit0	R/W
0x08	-			AUTO_START	UART_AUTO	R/W

bit[9:8] BAUD_RATE

Note) The baud rate change using these **BAUD_RATE** bits become effective immediately after write access completes.

These bits specifies the Baud Rate of UART interface.

00: Reserved

01: 460.8kbps

10: 230.4kbps

11: 115.2kbps

bit[1] AUTO_START (Only valid for UART Auto sampling)

Enables or disables the Auto Start function.

1: Automatic Start is enabled

0: Automatic Start is disabled

When Auto Start is enabled, the device enters sampling mode and sends sampling data automatically after completing internal initialization after powered on.

Write a "1" to this **AUTO_START** bit and **UART_AUTO** bit of this register to enable this function. Then execute **FLASH_BACKUP** of GLOB_CMD [0x0A(W1)] bit [3] to preserve the current register settings.

bit[0] UART_AUTO

Enables or disables the UART Auto sampling function.

1: UART Auto sampling is selected

0: UART Manual sampling is selected

If UART Auto sampling is active, register values such as FLAG, temperature, and accelerations (XACCL, YACCL, ZACCL) are continuously transmitted automatically according to the data output rate set by SMPL_CTRL [0x04(W1)] register.

In UART Manual sampling, register data is transmitted as a response to a register read command.

Note) For more info on UART Auto sampling refer to 6.2.4 UART Auto Sampling Operation and 6.3 Data Packet Format. The burst output data is configured by register setting in BURST_CTRL [0x0C(W1)].

7.14. GLOB_CMD Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x0B	-	-	-	MESMOD_STAT	-	NOT_READY	-	-	R

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x0A	SOFT_RST	-	-	-	FLASH_BACKUP	FLASH_RST	-	-	R/W

bit[12] MESMOD_STAT

This read-only status bit shows the status of the measurement condition at a sampling mode.

1: Reduced noise floor condition

0: Standard noise floor condition

bit[10] NOT_READY

Indicates whether this product currently ready. Immediately after power on, this bit is “1” and becomes “0” when the product is ready. After the power on, wait until the Power-On Start-Up Time has elapsed and then wait until this bit becomes “0” before starting sensor measurement. This bit is read-only.

1: Not ready

0: Ready

bit[7] SOFT_RST

Write “1” to execute software reset. After the software reset is completed, the bit automatically goes back to “0”.

bit[3] FLASH_BACKUP

Write “1” to save the current values of the control registers with the \bigcirc mark in the “Flash Backup” column of Table 7.1 to the non-volatile memory. After the execution is completed, the bit automatically goes back to “0”. After confirming this bit goes back to “0” and then check the result in **FLASH_BU_ERR** of **DIAG_STAT** [0x04(W0)] bit [0].

bit[2] FLASH_RST

Write “1” to resets the setting value saved in the nonvolatile memory to the factory default state. After completion of execution, it will automatically return to “0”. After confirming this bit goes back to “0” and then check the result in **FLASH_BU_ERR** of **DIAG_STAT** [0x04(W0)] bit [0]. The factory default state will be reflected to the registers after completing internal initialization after powered on or a reset.

7.15. BURST_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x0D	FLAG_OUT	TEMP_OUT	-	-	-	ACCX_OUT	ACCY_OUT	ACCZ_OUT	R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x0C	-	-	-	-	-	-	COUNT_OUT	CHKSM_OUT	R/W

These bits enable/disable the content in the output data for burst mode and UART Auto sampling.

bit[15] FLAG_OUT

Controls the output of FLAG status.

1: Enables output.

0: Disables output.

bit[10] ACCX_OUT

Controls the output of X axis acceleration / tilt angle. The output mode is selected by **OUTPUT_SEL_X** of register: SIG_CTRL [0x00 (W1)], bit [7].

1: Enables output.

0: Disables output.

bit[9] ACCY_OUT

Controls the output of Y axis acceleration / tilt angle. The output mode is selected by **OUTPUT_SEL_Y** of register: SIG_CTRL [0x00 (W1)], bit [6].

1: Enables output.

0: Disables output.

bit[8] ACCZ_OUT

Controls the output of Z axis acceleration / tilt angle. The output mode is selected by **OUTPUT_SEL_Z** of register: SIG_CTRL [0x00 (W1)], bit [5].

1: Enables output.

0: Disables output.

bit[1] COUNT_OUT

Controls the output of counter value.

1: Enables output.

0: Disables output.

bit[0] CHKSM_OUT

Controls the output of checksum.

1: Enables output.

0: Disables output.

Note) Please set "1: Enables output" to at least one bit of bit[8:10]. All outputs of acceleration / tilt angle values cannot be disabled at the same time.

7.16. FIR_UCMD Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x17	-	-	-	-	-	-	-	-	-

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x16	-	-	-	-	-	-	FIR_UCMD		R/W

bit[1:0] FIR_UCMD (FIR Filter User CoMmand)

These bits set the control command for setting the coefficient data of the user defined FIR filter.

READ	WRITE
00: execution complete	do not execute
01: reading in progress	read
10: writing in progress	write
11: not used	not used

7.17. FIR_UDATA Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x19	DATA_ERR	-	-	-	-	-	-	-	R

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x18	FIR_UDATA								R/W

bit[15] DATA_ERR

This bit shows the state of the read error on the coefficient data of the user defined FIR filter.

1: Read error

0: Normal operation

bit[7:0] FIR_UDATA(FIR Filter User DATA)

Set the coefficient data (binary) of the user defined FIR filter.

7.18. FIR_UADDR Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x1B	FIR_UADDR_HIGH								R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x1A	FIR_UADDR_LOW								R/W

bit[15:8] FIR_UADDR_HIGH

Upper address of the coefficient data of the user FIR filter.

bit[7:0] FIR_UADDR_LOW

Lower address of the coefficient data of the user FIR filter.

Note) This address is automatically incremented after the read / write command is executed.

Note) The setting range is from 0x0800 to 0x0FFF. It cannot be set outside the range.

7.19. LONGFILT_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x1D	-	-	-	-	-	-	-	-	-

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x1C	-	-	-	-	-	-	FILT_SEL	FILT_EN	R/W ¹

bit[1] FILT_SEL

This bit selects the type of long period filter.

1: HPF

0: LPF

bit[0] FILT_EN

This bit enable / disable long-period filter.

1: Enable

0: Disable

7.20. LONGFILT_TAP Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x1F	-	-	-	-	-	-	-	-	-

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x1E	-	-	-	-	TAP_SIZE				R/W

bit[3:0] TAP_SIZE

These bits set the tap size of the long period filter.

0001: tap2

0010: tap4

0011: tap8

0100: tap16

0101: tap32

0110: tap64

0111: tap128

1000: tap256

1001: tap512

1010: tap1024

1011: tap2048

1100: tap4096

1101~1111: not used

7.21. XA_OFFSET Register (Window 1)

Addr (Hex)	Bit15	...	Bit8	R/W
0x2D	XOFFSET_HIGH_H			R/W

Addr (Hex)	Bit7	...	Bit0	R/W
0x2C	XOFFSET_HIGH_L			R/W

bit[15:0] XOFFSET_HIGH

Sets the X-axis acceleration offset value upper word.

Addr (Hex)	Bit15	...	Bit8	R/W
0x2F	XOFFSET_LOW_H			R/W

Addr (Hex)	Bit7	...	Bit0	R/W
0x2E	XOFFSET_LOW_L			R/W

bit[15:0] XOFFSET_LOW

Sets the X-axis acceleration offset value lower word.

7.22. YA_OFFSET Register (Window 1)

Addr (Hex)	Bit15	...	Bit8	R/W
0x31	YOFFSET_HIGH_H			R/W

Addr (Hex)	Bit7	...	Bit0	R/W
0x30	YOFFSET_HIGH_L			R/W

bit[15:0] YOFFSET_HIGH

Sets the Y-axis acceleration offset value upper word.

Addr (Hex)	Bit15	...	Bit8	R/W
0x33	YOFFSET_LOW_H			R/W

Addr (Hex)	Bit7	...	Bit0	R/W
0x32	YOFFSET_LOW_L			R/W

bit[15:0] YOFFSET_LOW

Sets the Y-axis acceleration offset value lower word.

7.23. ZA_OFFSET Register (Window 1)

Addr (Hex)	Bit15	...	Bit8	R/W
0x35	ZOFFSET_HIGH_H			R/W

Addr (Hex)	Bit7	...	Bit0	R/W
0x34	ZOFFSET_HIGH_L			R/W

bit[15:0] ZOFFSET_HIGH

Sets the Z-axis acceleration offset value upper word.

Addr (Hex)	Bit15	...	Bit8	R/W
0x37	ZOFFSET_LOW_H			R/W

Addr (Hex)	Bit7	...	Bit0	R/W
0x36	ZOFFSET_LOW_L			R/W

bit[15:0] ZOFFSET_LOW

Sets the Z-axis acceleration offset value upper word.

7.24. XA_ALARM Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x47	XALARM_UP								R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x46	XALARM_LO								R/W

bit[15:8] XALARM_UP

Sets the acceleration upper limit value to be determined by XALARM_ERR of register: FLAG [0x06 (W0)], bit [4].

Data format: 8bit, two's complement format

Setting unit: G

Setting range: -15 to +15 (can not be set to a value outside the range)

bit[7:0] XALARM_LO

Sets the acceleration lower limit value to be determined by XALARM_ERR of register: FLAG [0x06 (W0)], bit [4]

The setting specification is the same as XALARM_UP

7.25. YA_ALARM Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x49	YALARM_UP								R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x48	YALARM_LO								R/W

bit[15:8] YALARM_UP

Sets the acceleration upper limit value to be determined by YALARM_ERR of register: FLAG [0x06 (W0)], bit [3]

Data format: 8bit, two's complement format

Setting unit: G

Setting range: -15 to +15 (can not be set to a value outside the range)

bit[7:0] YALARM_LO

Sets the acceleration lower limit value to be determined by YALARM_ERR of register: FLAG [0x06 (W0)], bit [3]

The setting specification is the same as YALARM_UP

7.26. ZA_ALARM Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x4B	ZALARM_UP								R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x4A	ZALARM_LO								R/W

bit[15:8] ZALARM_UP

Sets the acceleration upper limit value to be determined by ZALARM_ERR of register: FLAG [0x06 (W0)], bit [2]

Data format: 8bit, two's complement format

Setting Unit: G

Setting rang: -15 to +15 (can not be set to a value outside the range)

bit[7:0] ZALARM_LO

Sets the acceleration lower limit value to be determined by ZALARM_ERR of register: FLAG [0x06 (W0)], bit [2]

The setting specification is the same as ZALARM_UP

7.27. PROD_ID Register (Window 1)

Addr (Hex)	Bit15	...	Bit0	R/W
0x6A	PROD_ID1			R
0x6C	PROD_ID2			R
0x6E	PROD_ID3			R
0x70	PROD_ID4			R

bit[15:0] Product ID

Note) These registers return the product model number of the internal sensor represented in ASCII code.

Product ID return value is A352AD10

PROD_ID1: 0x3341

PROD_ID2: 0x3235

PROD_ID3: 0x4441

PROD_ID4: 0x3031

7.28. VERSION Register (Window 1)

Addr (Hex)	Bit15	...	Bit0	R/W
0x72	VERSION			R

bit[15:0] Version

This register returns the Firmware Version

7.29. SERIAL_NUM Register (Window 1)

Addr (Hex)	Bit15	...	Bit0	R/W
0x74	SERIAL_NUM1			R
0x76	SERIAL_NUM2			R
0x78	SERIAL_NUM3			R
0x7A	SERIAL_NUM4			R

bit[15:0] Serial Number

Note) These registers return the serial number of the internal sensor represented in ASCII code.

For example, if the Serial Number is 01234567 then the return value is:

SERIAL_NUM1: 0x3130

SERIAL_NUM2: 0x3332

SERIAL_NUM3: 0x3534

SERIAL_NUM4: 0x3736

7.30. WIN_CTRL Register (Window 0,1)

Addr (Hex)	Bit15	...	Bit8	R/W
0x7F				-

Addr (Hex)	Bit7	...	Bit0	R/W
0x7E	WINDOW_ID			R/W

bit[7:0] WINDOW_ID

Selects the desired register window by writing the window number to this register.

0x00 :Window 0

0x01 :Window 1

0x02-0xFF: Unused

8. SAMPLE PROGRAM FLOW

The following describes the recommended procedures for operating this device

8.1. FLOW

8.1.1. Power-on sequence

Power-on sequence is as follows.

(a) power-on.

(b) Wait Power-On Start-Up Time.

(c) Wait until NOT_READY bit goes to 0. NOT_READY is GLOB_CMD[0x0A(W1)]'s bit[10].

```
TXdata={0xFE,0x01,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=1) */
```

```
TXdata={0x0A,0x00,0x0d}.          /* GLOB_CMD read command */
```

```
TXdata={0x0A,MSByte,LSByte,0x0d}. /* get response */
```

Confirm NOT_READY bit.

When NOT_READY becomes 0, it ends. Otherwise , please repeat (c).

(d) Confirm HARD_ERR bits. HARD_ERR is DIAG_STAT[0x04(W0)]'s bit[7:5].

```
TXdata={0xFE,0x00,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=0) */
```

```
TXdata={0x04,0x00,0x0d}.          /* DIAG_STAT read command */
```

```
TXdata={0x04,MSByte,LSByte,0x0d}. /* get response */
```

Confirm HARD_ERR is 000.

If HARD_ERR is 000, the Accelerometer is OK. Otherwise, the Accelerometer is faulty.

8.1.2. Register read and write

[Read Example]

To read a 16bit-data from a register(addr=0x02 / WINDOW=0).

```
TXdata={0xFE,0x00,0x0d}.          /* WINDOW_ID write command.(WINDOW=0) */
```

```
TXdata={0x02,0x00,0x0d}.          /* MODE_CTRL read command */
```

```
RXdata={0x02,0x04,0x00,0x0d}      /* get response*/
```

0x04 in 2nd byte of RXdata is Configuration mode.

0x00 in 3rd byte of RXdata is Reserved.

Please note that read data unit is 16bit, and Most Significant Byte first.

[Write Example]

To write a 8bit-data into a register(addr=0x03 / WINDOW=0).

```
TXdata={0xFE,0x00,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=0) */
```

```
TXdata={0x83,0x01,0x0d}.          /* MODE_CTRL(H) write command.(move to Sampling mode) */
```

There is no response at Write.

By sending this command, the Accelerometer moves to Sampling mode.

Please note that write data unit is 8bit.

8.1.3. Sampling data

[Sample Flow 1 (UART Auto sampling)]

Power-on sequence. Please refer to Chapter 8.1.1.

Filter setting sequence. Please refer to Chapter 8.1.9

```
TXdata={0xFE,0x01,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=1) */
TXdata={0x85,0x04,0x0d}.          /* SMPL_CTRL(H) write command.(200Sps) */
TXdata={0x88,0x01,0x0d}.          /* UART_CTRL(L) write command.(UART Auto sampling) */
TXdata={0x8C,0x02,0x0d}.          /* BURST_CTRL(L) write command.(COUNT=on) */
TXdata={0x8D,0x47,0x0d}.          /* BURST_CTRL(H) write command.(TEMP=on,
ACC_XYZ=on) */
TXdata={0xFE,0x00,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=0) */
TXdata={0x83,0x01,0x0d}.          /* MODE_CTRL(H) write command.(move to Sampling
mode) */
```

receive sampling data.

```
(a)RXdata={0x80, TEMP_HIGH_Hi, TEMP_HIGH_Lo, TEMP_LOW_Hi, TEMP_LOW_Lo,
XACCL_HIGH_Hi, XACCL_HIGH_Lo, XACCL_LOW_Hi, XACCL_LOW_Lo,
YACCL_HIGH_Hi, YACCL_HIGH_Lo, YACCL_LOW_Hi, YACCL_LOW_Lo,
ZACCL_HIGH_Hi, ZACCL_HIGH_Lo, ZACCL_LOW_Hi, ZACCL_LOW_Lo,
COUNT_Hi, COUNT_Lo, 0x0d}
```

repeat (a).

```
TXdata={0x83,0x02,0x0d}.          /* MODE_CTRL(H) write command.(return to Configuration
mode) */
```

[Sample Flow 2(UART burst mode)]

Power-on sequence. Please refer to Chapter 8.1.1

Filter setting sequence. Please refer to Chapter 8.1.9

```
TXdata={0xFE,0x01,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=1) */
TXdata={0x85,0x04,0x0d}.          /* SMPL_CTRL(H) write command.(200Sps) */
TXdata={0x88,0x00,0x0d}.          /* UART_CTRL(L) write command.(UART Manual sampling)
*/
TXdata={0x8C,0x02,0x0d}.          /* BURST_CTRL(L) write command.(COUNT=on) */
TXdata={0x8D,0x47,0x0d}.          /* BURST_CTRL(H) write command.(TEMP=on,
ACC_XYZ=on) */
TXdata={0xFE,0x00,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=0) */
```

TXdata={0x83,0x01,0x0d}. /* MODE_CTRL(H) write command.(move to Sampling mode) */

receive sampling data.

(b)TXdata={0x80,0x00,0x0d}. /* BURST(L) write command */

(c)RXdata={0x80, TEMP_HIGH_Hi, TEMP_HIGH_Lo, TEMP_LOW_Hi, TEMP_LOW_Lo,
XACCL_HIGH_Hi, XACCL_HIGH_Lo, XACCL_LOW_Hi, XACCL_LOW_Lo,
YACCL_HIGH_Hi, YACCL_HIGH_Lo, YACCL_LOW_Hi, YACCL_LOW_Lo,
ZACCL_HIGH_Hi, ZACCL_HIGH_Lo, ZACCL_LOW_Hi, ZACCL_LOW_Lo,
COUNT_Hi, COUNT_Lo, 0x0d}

repeat from (a) to (c).

TXdata={0x83,0x02,0x0d}. /* MODE_CTRL(H) write command.(return to Configuration mode) */

[Notes]

Please note that read data unit is 16bit, and Most Significant Byte first.

Please note that write data unit is 8bit.

X ACCL_HIGH_Hi: means MSByte of ACCL_HIGH data

X ACCL_HIGH_Lo: means LSByte of ACCL_HIGH data

8.1.4. Self test

Selftest is as follows.

Power-on sequence. Please refer to Chapter 8.1.1

(a) Send self test command.

TXdata={0xFE,0x01,0x0d}. /* WINDOW_ID(L) write command.(WINDOW=1) */

TXdata={0x83,0x04,0x0d}. /* MSC_CTRL(H) write command.(Acc Test) */

(b) Wait until selftest has finished.

Wait until ACC_TEST bit goes to 0. ACC_TEST is MSC_CTRL[0x02(W1)]'s bit[10].

TXdata={0x02,0x00,0x0d}. /* MSC_CTRL read command */

RXdata={0x02,MSByte,LSByte,0x0d}. /* get response */

Confirm ACC_TEST bit.

When ACC_TEST becomes 0, it ends. Otherwise , please repeat (b).

(c) Confirm the result.

Confirm ACC_ERR bits. ACC_ERR is DIAG_STAT[0x04(W0)]'s bit[15:12].

TXdata={0xFE,0x00,0x0d}. /* WINDOW_ID(L) write command.(WINDOW=0) */

```
TXdata={0x04,0x00,0x0d}.          /* DIAG_STAT read command */
RXdata={0x04,MSByte,LSByte,0x0d}. /* get response */
Confirm each ACC_ERR is 0.
If each ACC_ERR is 0, the result is OK. Otherwise, the result is NG.
```

8.1.5. Flash Test

Flash test is as follows.

Power-on sequence. Please refer to Chapter 8.1.1

(a) Send flash test command.

```
TXdata={0xFE,0x01,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=1) */
TXdata={0x83,0x08,0x0d}.          /* MSC_CTRL(H) write command.(Flash Test) */
```

(b) Wait until flash test has finished.

Wait until FLASH_TEST bit goes to 0. FLASH_TEST is MSC_CTRL[0x02(W1)]'s bit[11].

```
TXdata={0x02,0x00,0x0d}.          /* MSC_CTRL read command */
RXdata={0x02,MSByte,LSByte,0x0d}. /* get response */
Confirm FLASH_TEST bit.
When FLASH_TEST becomes 0, it ends. Otherwise , please repeat (b).
```

(c) Confirm the result.

Confirm FLASH_ERR bits. FLASH_ERR is DIAG_STAT[0x04(W0)]'s bit[2].

```
TXdata={0xFE,0x00,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=0) */
TXdata={0x04,0x00,0x0d}.          /* DIAG_STAT read command */
RXdata={0x04,MSByte,LSByte,0x0d}. /* get response */
Confirm FLASH_ERR is 0.
If FLASH_ERR is 0, the result is OK. Otherwise, the result is NG.
```

8.1.6. Software Reset

Software reset is as follows.

Power-on sequence. Please refer to Chapter 8.1.1

(a) Send software reset command.

TXdata={0xFE,0x01,0x0d}.

/* WINDOW_ID(L) write command.(WINDOW=1) */

TXdata={0x8A,0x80,0x0d}.

/* GLOB_CMD(L) write command.(Software reset)

*/

(b) Wait Reset Recovery Time.

8.1.7. Flash Backup

Flash backup is as follows.

Power-on sequence. Please refer to Chapter 8.1.1

(a) Send flash backup command.

TXdata={0xFE,0x01,0x0d}.

/* WINDOW_ID(L) write command.(WINDOW=1) */

TXdata={0x8A,0x08,0x0d}.

/* GLOB_CMD(L) write command.(Flash backup) */

(b) Wait until flash backup has finished.

Wait until FLASH_BACKUP bit goes to 0. FLASH_BACKUP is GLOB_CMD[0x0A(W1)]'s bit[3].

TXdata={0x0A,0x00,0x0d}.

/* GLOB_CMD read command */

RXdata={0x0A,MSByte,LSByte,0x0d}.

/* get response */

Confirm FLASH_BACKUP bit.

When FLASH_BACKUP becomes 0, it ends. Otherwise , please repeat (b).

(c) Confirm the result.

Confirm FLASH_BU_ERR bits. FLASH_BU_ERR is DIAG_STAT[0x04(W0)]'s bit[0].

TXdata={0xFE,0x00,0x0d}.

/* WINDOW_ID(L) write command.(WINDOW=0) */

TXdata={0x04,0x00,0x0d}.

/* DIAG_STAT read command */

RXdata={0x04,MSByte,LSByte,0x0d}.

/* get response */

Confirm FLASH_BU_ERR is 0.

If FLASH_BU_ERR is 0, the result is OK. Otherwise, the result is NG.

8.1.8. Flash Reset

Flash Reset is as follows.

Power-on sequence. Please refer to Chapter 8.1.1

(a) Send flash reset command.

```
TXdata={0xFE,0x01,0x0d}.      /* WINDOW_ID(L) write command.(WINDOW=1) */
TXdata={0x8A,0x04,0x0d}.      /* GLOB_CMD(L) write command.(Flash Reset) */
```

(b) Wait until flash reset has finished.

Wait until FLASH_RST bit goes to 0. FLASH_RST is GLOB_CMD[0x0A(W1)]'s bit[2].

```
TXdata={0x0A,0x00,0x0d}.      /* GLOB_CMD read command */
```

```
RXdata={0x0A,MSByte,LSByte,0x0d}. /* get response */
```

Confirm FLASH_RST bit.

When FLASH_RST becomes 0, it ends. Otherwise , please repeat (b).

(c) Confirm the result.

Confirm FLASH_BU_ERR bits. FLASH_BU_ERR is DIAG_STAT[0x04(W0)]'s bit[0].

```
TXdata={0xFE,0x00,0x0d}.      /* WINDOW_ID(L) write command.(WINDOW=0) */
```

```
TXdata={0x04,0x00,0x0d}.      /* DIAG_STAT read command */
```

```
RXdata={0x04,MSByte,LSByte,0x0d}. /* get response */
```

Confirm FLASH_BU_ERR is 0.

If FLASH_BU_ERR is 0, the result is OK. Otherwise, the result is NG.

(d) Power off and on , or reset.

8.1.9. Filter setting

Filter setting is as follows.

Power-on sequence. Please refer to Chapter 8.1.1

(a) Send filter setting command for FIR kaiser filter (TAP512, fc60).

```
TXdata={0xFE,0x01,0x0d}.      /* WINDOW_ID(L) write command.(WINDOW=1) */
```

```
TXdata={0x86,0x08,0x0d}.      /* FILTER_CTRL(L) write command.(Filter setting) */
```

(b) Wait until filter setting has finished.

Wait until FILTER_STAT bit goes to 0. FILTER_STAT is FILTER_CTRL[0x06(W1)]'s bit[5].

```
TXdata={0x06,0x00,0x0d}.      /* FILTER_CTRL read command */
```

```
RXdata={0x06,MSByte,LSByte,0x0d}. /* get response */
```

Confirm FILTER_STAT bit.

When FILTER_STAT becomes 0, it ends. Otherwise , please repeat (b).

8.1.10. User Defined FIR Filter coefficients setting

User Defined FIR Filter coefficients setting is as follows.

Power-on sequence. Please refer to Chapter 8.1.1

[Write Sequence]

(a) Send filter coefficient address command.

TXdata={0xFE,0x01,0x0d}. /* WINDOW_ID(L) write command.(WINDOW=1) */

First, set the start address (0x0800),

TXdata={0x9B,0x08,0x0d}. /* FIR_UADDR(H) write command.(Address High Byte) */

TXdata={0x9A,0x00,0x0d}. /* FIR_UADDR(L) write command.(Address Low Byte) */

(b) Send filter coefficient data command.

For example, if the coefficient data is 0x1C19D153, send in order from the lower byte(0x53).

TXdata={0x98,0x53,0x0d}. /* FIR_UDATA(L) write command */

(c) Send filter coefficient control command.

TXdata={0x96,0x02,0x0d}. /* FIR_UCMD(L) write command (Wirte execution)*/

(d) Wait until Write execution has finished.

Wait until FIR_UCMD bit goes to 00. FIR_UCMD is FIR_UCMD[0x16(W1)]'s bit[1:0].

TXdata={0x16,0x00,0x0d}. /* FIR_UCMD read command */

RXdata={0x16,MSByte,LSByte,0x0d}. /* get response */

Confirm FIR_UCMD bit.

When FIR_UCMD becomes 00, it ends. Otherwise , please repeat (d).

(e) Repeat from (b) to (d) until sending all coefficients.

(f) Send filter setting command for User Defined FIR Filter. Please refer to Chapter 8.1.9

notes

The coefficient data unit is 32bit, and little-endian format.

After the byte has completed writing, the address is automatically incremented by 1.

[Read Sequence]

(a) Send filter coefficient address command.

```

TXdata={0xFE,0x01,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=1) */
First, set the start address (0x0800),
TXdata={0x9B,0x08,0x0d}.          /* FIR_UADDR(H) write command.(Address High Byte) */
TXdata={0x9A,0x00,0x0d}.          /* FIR_UADDR(L) write command.(Address Low Byte) */

```

(b) Send filter coefficient control command.

```

TXdata={0x96,0x01,0x0d}.          /* FIR_UCMD(L) write command (Read execution)*/

```

(c) Wait until Read execution has finished.

Wait until FIR_UCMD bit goes to 00. FIR_UCMD is FIR_UCMD[0x16(W1)]'s bit[1:0].

```

TXdata={0x16,0x00,0x0d}.          /* FIR_UCMD read command */

```

```

RXdata={0x16,MSByte,LSByte,0x0d}. /* get response */

```

Confirm FIR_UCMD bit.

When FIR_UCMD becomes 00, it ends. Otherwise , please repeat (c).

(d) Send filter coefficient data command.

```

TXdata={0x18,0x00,0x0d}.          /* FIR_UDATA read command */

```

```

RXdata={0x18,MSByte,LSByte,0x0d}. /* get response */

```

(e) Repeat from (b) to (d) until reading all coefficients.

notes

The coefficient data unit is 32bit, and little-endian format.

After the byte has completed reading, the address is automatically incremented by 1.

8.1.11. Auto Start

Auto Start is as follows.

Power-on sequence. Please refer to Chapter 8.1.1

(a) Set registers.

```

TXdata={0xFE,0x01,0x0d}.          /* WINDOW_ID(L) write command.(WINDOW=1) */

```

```

TXdata={0x85,0x04,0x0d}.          /* SMPL_CTRL(H) write command.(200Sps) */

```

```

TXdata={0x86,0x08,0x0d}.          /* FILTER_CTRL(L) write command.(Filter setting TAP=512
fc60) */

```

```

TXdata={0x88,0x03,0x0d}.          /* UART_CTRL(L) write command.(UART Auto sampling, Auto
start=on) */

```

```

TXdata={0x8C,0x02,0x0d}.          /* BURST_CTRL(L) write command.(COUNT=on) */

```

```
TXdata={0x8D,0x47,0x0d}.          /* BURST_CTRL(H) write command.(TEMP=on, ACC_XYZ=on)
*/
(b) Execute Flash backup. Please refer to Chapter 8.2.7.
(c) power-off.
(d) power-on.
(e) Wait Power-On Start-Up Time.
(f) receive sampling data.
(ii) RXdata={0x80, TEMP_HIGH_Hi, TEMP_HIGH_Lo, TEMP_LOW_Hi, TEMP_LOW_Lo,
            XACCL_HIGH_Hi, XACCL_HIGH_Lo, XACCL_LOW_Hi, XACCL_LOW_Lo,
            YACCL_HIGH_Hi, YACCL_HIGH_Lo, YACCL_LOW_Hi, YACCL_LOW_Lo,
            ZACCL_HIGH_Hi, ZACCL_HIGH_Lo, ZACCL_LOW_Hi, ZACCL_LOW_Lo,
            COUNT_Hi, COUNT_Lo, 0x0d}
    repeat from (i) to (ii).
(g) If you want to stop sampling,
    TXdata={0x83,0x02,0x0d}.          /* MODE_CTRL(H) write command.(return to Configuration
mode) */
```

9. HANDLING NOTES

9.1. CAUTIONS FOR ATTACHING

- The product contains quartz crystal oscillator created by microfabrication. Take precaution to prevent falling or excessive impact. Do not use the product after an accidental fall or it experiences excessive impact. The possibility of a failure and risk of malfunction from failure increases.
- Excessive vibration, shock, continuous stress, or sudden temperature change may increase the possibility of failure.
- Please consult us before the unit is used in an environment where there is acute vibration out of the measurement band.
- The product should be kept powered on for more than 15 minutes to measure with highest precision and accuracy.
- Do not connect the product to the network with the supply voltage turned on.
- When attaching the product, ensure that the product is properly mounted to avoid mechanical stress such as warping or twisting. In addition, ensure appropriate torque is applied when tightening the screws but not too excessive to cause the mount of the product to deform or break. Use screw locking techniques as necessary.
- When setting up the product, ensure that the equipment, jigs, tools, and workers maintain a good ground in order not to generate high voltage leakage. Applying over current or static electricity to the product may damage the product permanently.
- When installing the product, ensure that metallic or other conductive material do not enter the product. Otherwise, malfunction or damage of the product may result.
- If excessive shock is applied to the product when, for example, the product falls, the quality of the product may be degraded. Ensure that the product does not fall when you handle it.
- Before you start using the product to obtain measurements, test it in the actual equipment under the actual operating environment to confirm proper operation.
- When connecting a cable to this product, tighten the screw enough after inserting it completely. This product may not satisfy IP67 if tightening is insufficient.
- Do not use the product in a situation where power is always applied to the joint of connector.
- Ensure that the signals are wired correctly with attention to the name and the polarity of each signal.
- Since the product has capacitors inside, Inrush current occurs immediately after power-on. Evaluate in the actual environment in order to check the effect of the supply voltage sag caused by inrush current in the system.

9.2. OTHER CAUTIONS

- This product is water-proof and dust-proof in conformity with IP67. We do not guarantee the operation of the product when the product is exposed to condensation, dust, oil, corrosive gas (salt, acid, alkaline, etc), or direct sunlight which surpass IP67. Do not use this product under water.
- This product is not designed to be radiation resistant.
- Never use this product if the operating condition is over the absolute maximum rating. Otherwise, permanent damage to the product may result.
- If the product is exposed to excessive external noise or other similar conditions, degradation of the precision, malfunction, or damage to the product may result. The system needs to be designed so that the noise itself is suppressed or the system is immune to the noise.
- This product is not designed to be used in equipment that demands extremely high reliability and where its failure may threaten human life or property (for example, aerospace equipment, submarine repeater, nuclear power control equipment, life support equipment, medical equipment, transportation control equipment, etc.). Seiko Epson Corporation will not be liable for any damages caused by the use of the product for those applications.
- Do not apply shock or vibration to the packing box. Do not spill water over the packing box. Do not store or use the product in an environment where dew condensation occurs due to rapid temperature change.
- Do not put mechanical stress on the product while it is stored.
- Do not alter or disassemble the product.

- Do not use in water except if it gets temporarily wet based on IP67. This product does not achieve the sufficient waterproof performance if the the connector is mated incorrectly or that the mating connector does not satisfy IP67.
- The power supply to this product must satisfy the voltage rating within 2 seconds after it is turned on.
- Do not use thinner or similar liquids on this product. When cleaning this product, alcohol may be used.
- It is recommended that this product be installed horizontally (± 5 deg.) for normal use.

9.3. LIMITED WARRANTY

- The warranty period for this product is 12 months from the date of shipment.
- During the warranty period, if any defect attributable to our company is found, we will replace the product free of charge.

10. PART NUMBER / ORDERING INFO.

The following is the ordering code for the product:

Product Name	Model Name	Product Number	Comment
Accelerometer for RS-422 Interface	M-A552AR10	X2F000031000300	

11. STANDARDS AND APPROVALS

The following standards are applied only to the unit that are labeled. (EMC is tested using the EPSON power supplies.)

11.1. NOTICE

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

The connection of a non-shielded interface cable to this product will invalidate the EMC standards of the device.

Any changes or modifications not expressly approved by Seiko Epson Corporation could void your authority to operate the equipment.

11.2. CE Statement

This product conforms to the following Directives and Norms,

Directive 2014/30/EU:
EN61326-1 Class A

Directive 2011/65/EU:
EN IEC 63000:2018

Representative information,
Epson Europe Electronics GmbH
Riesstrasse 15
80992 Munich
Germany

11.3. RoHS & WEEE

The crossed out wheeled bin label that can be found on your product indicates that this product should not be disposed of via the normal household waste stream. To prevent possible harm to the environment or human health please separate this product from other waste streams to ensure that it can be recycled in an environmentally sound manner. For more details on available collection facilities please contact your local government office or the retailer where you purchased this product.

AEEE Yönetmeliğine Uygundur.

Обладнання відповідає вимогам Технічного регламенту обмеження використання деяких небезпечних речовин в електричному та електронному обладнанні

11.4. UKCA Statement

This product conforms to the following Directives and Norms,

Directive 2014/30/EU
BS EN 61326-1 Class A

Directive 2011/65/EU:
EN IEC 63000:2018

Representative information,
Epson (UK) Ltd. Westside
Westside, London Road, Hemel
Hempstead, Hertfordshire, HP3 9TD,
United Kingdom

11.5. FCC Compliance Statement for American users

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference, and
- (2) This device must accept any interference received, including interference that may cause undesired operation.

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

11.6. Industry ICES Compliance Statement for Canadian users

CAN ICES-3(A)/NMB-3(A)

REVISION HISTORY

AMERICA

EPSON AMERICA, INC.

Headquarter:
3131 Katella Ave.
Los Alamitos, CA 90720, USA
Phone: +1-800-463-7766

San Jose Office:
2860 Zanker Road, Suite 204,
San Jose, CA 95134, U.S.A
Phone: +1-800-463-7766

EUROPE

EPSON EUROPE ELECTRONICS GmbH

Riesstrasse 15, 80992 Munich,
GERMANY
Phone: +49-89-14005-0 FAX: +49-89-14005-110

ASIA

EPSON (CHINA) CO., LTD.

4F, Tower 1 of China Central Place, 81 Jianguo Street, Chaoyang
District, Beijing 100025 CHINA
Phone: +86-400-810-9972 X ext.2
Mail EPSON_MSM@ecc.epson.com.cn

EPSON SINGAPORE PTE. LTD.

438B Alexandra Road, Block B Alexandra TechnoPark,
#04-01/04, Singapore 119968
Phone: +65-6586-5500 FAX: +65-6271-3182

EPSON TAIWAN TECHNOLOGY & TRADING LTD.

15F, No.100, Song Ren Road, Taipei 110, TAIWAN
Phone: +886-2-8786-6688 Fax: +886-2-8786-6660

EPSON KOREA Co., Ltd.

10F Posco Tower Yeoksam, Teheranro 134 Gangnam-gu,
Seoul, 06235 KOREA
Phone: +82-2-558-4270 Fax: +82-2-3420-6699

JAPAN

SEIKO EPSON CORPORATION.

MD SALES & MARKETING DEPT.

JR Shinjuku Miraina Tower, 4-1-6 Shinjuku, Shinjuku-ku, Tokyo,
160-8801, Japan
Phone: +81-3-6682-4322 FAX: +81-3-6682-5016