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**EPSON**  
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IMU (Inertial Measurement Unit)  
**M-G370PDS0**  
**Data Sheet**



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## 1. General Description

The M-G370PDS0 is a small form factor inertial measurement unit (IMU) with 6 degrees of freedom: triaxial angular rates and linear accelerations, and provides high-stability and high-precision measurement capabilities with the use of high-precision compensation technology. A variety of calibration parameters are stored in memory of the IMU, and are automatically reflected in the measurement data being sent to the application after the power of the IMU is turned on. With general-purpose SPI/UART support for host communications, the M-G370PDS0 reduces technical barriers for users to introduce inertial measurement and minimizes design resources to implement inertial movement analysis and control applications. The features of the IMU such as high stability, high precision, and small size make it easy to create and differentiate applications in various fields of industrial systems.

### 1.1 Features

- Small Size, Lightweight : 24x24x10 mm<sup>3</sup>, 10grams
- Low-Noise, High-stability
  - Gyro Bias Instability : 0.8 °/h
  - Angular Random Walk : 0.03 °/√h
- Initial Bias Error : 360 °/h (1σ) / 2 mG (1σ)
- 6 Degrees Of Freedom
  - Triple Gyroscopes : ±200 °/s
  - Tri-Axis Accelerometer : ±10 G
- 16/32bit data resolution
- Digital Serial Interface : SPI / UART
- Calibrated Stability (Bias, Scale Factor, Axial Alignment)
- Data Output Rate : to 2 k Sps
- External Trigger Input / External Counter Reset Input
- Delta Angle/Delta Velocity Output
- Calibration Temperature Range: -40 °C to +85 °C
- Operating Temperature Range : -40 °C to +85 °C
- Single Voltage Supply : 3.3 V
- Low Power Consumption : 16 mA (Typ.)

### 1.2 Applications

- Unmanned Vehicles
- Antenna Platform Stabilization
- Camera Gimbals
- Vibration Control and Stabilization
- Navigation Systems

### 1.3 Functional Block Diagram

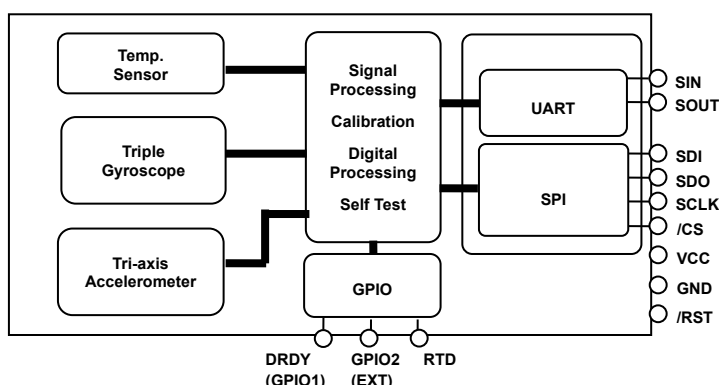


Figure 1.1 Functional Block Diagram

## 2. Product Specifications

### 2.1 Absolute Maximum Ratings

Table 2.1 Absolute Maximum Ratings

Parameter	Min.	Typ.	Max.	Unit
Vcc to GND	-0.3	—	4.8	V
Digital Input Voltage to GND	-0.3	—	Vcc +0.3	V
Digital Output Voltage to GND	-0.3	—	Vcc +0.3	V
Storage Temperature Range	-40	—	85	°C
Acceleration / Shock (Half-sine 0.5msec)	—	—	1000	G
Sine Sweep Vibration (10~2kHz)	—	—	10	G
Random Vibration (20~2kHz)	—	—	20	Grms

### Precautions about ESD

Electrostatic discharge (ESD) may damage the product.

When you store or handle the product, take appropriate preventive measures against electrostatic discharge (ESD).

Damages caused by electrostatic discharge (ESD) range from small performance degradation, partial malfunction, to complete breakdown.

This is a high-precision product. Even small performance degradation may cause the product not to conform to the specifications.

### 2.2 Recommended Operating Condition

Table 2.2 Recommended Operating Conditions

Parameter	condition	Min.	Typ.	Max.	Unit
Vcc to GND		3.15	3.3	3.45	V
Digital Input Voltage to GND		GND	—	Vcc	V
Digital Output Voltage to GND		-0.3	—	Vcc +0.3	V
Calibration Temperature Range	Performance parameters are applicable	-40	—	85	°C
Operating Temperature Range		-40	—	85	°C

## 2.3 Characteristics and Electrical Specifications

Table 2.3 Sensor Specifications

$T_A=25\text{ }^\circ\text{C}$ ,  $V_{CC}=3.3\text{ V}$ , angular rate=0  $^\circ/\text{s}$ ,  $\leq\pm 1\text{ G}$ , unless otherwise noted.

Parameter	Test Conditions / Comments	Min.	Typ.	Max.	Unit
GYRO sensor					
Sensitivity					
Output Range		-	$\pm 200$	-	$^\circ/\text{s}$
Scale Factor	16 bit	-0.2%	150	+0.2%	LSB / ( $^\circ/\text{s}$ )
	32 bit	-0.2%	$150 \times (2^{16})$	+0.2%	
Nonlinearity (Best fit straight line)	1 $\sigma$ , $<130\text{ }^\circ/\text{s}$	-	0.05	-	% of FS
	1 $\sigma$ , $>130\text{ }^\circ/\text{s}$	-	0.2	-	% of FS
Misalignment	1 $\sigma$ , Axis-to-axis, $\Delta = 90^\circ$ ideal	-	0.01	-	$^\circ$
Bias					
Initial Error	1 $\sigma$ , $-40\text{ }^\circ\text{C} \leq T_A \leq +85\text{ }^\circ\text{C}$	-	360	-	$^\circ/\text{h}$
Repeatability	1 $\sigma$ , turn-on to turn-on *3	-	36	-	$^\circ/\text{h}$
Bias Instability	Average	-	0.8	-	$^\circ/\text{h}$
Angular Random Walk	Average	-	0.03	-	$^\circ/\sqrt{\text{h}}$
Linear Acceleration Effect	Average	-	18	-	( $^\circ/\text{h}$ )/G
Noise Density	f = 10 Hz to 20 Hz	-	2.52	-	( $^\circ/\text{h}$ )/ $\sqrt{\text{Hz}}$ , rms
Frequency Property					
3 dB Bandwidth		-	189	-	Hz
ACCELEROMETERS					
Sensitivity					
Output Range		-	$\pm 10$	-	G
Scale Factor	16 bit	-0.1%	2.5	+0.1%	LSB /mG
	32 bit	-0.1%	$2.5 \times (2^{16})$	+0.1%	
Nonlinearity (Best fit straight line)	1 $\sigma$ , $<5\text{ G}$	-	0.1	-	% of FS
Misalignment	1 $\sigma$ , Axis-to-axis, $\Delta = 90^\circ$ ideal	-	0.01	-	$^\circ$
Bias					
Initial Error	1 $\sigma$ , $-40\text{ }^\circ\text{C} \leq T_A \leq +85\text{ }^\circ\text{C}$	-	2	-	mG
Repeatability	1 $\sigma$ , turn-on to turn-on *3	-	2	-	mG
Bias Instability	Average	-	12	-	$\mu\text{G}$
Velocity Random Walk	Average	-	0.025	-	(m/s)/ $\sqrt{\text{h}}$
Noise Density	f = 10 Hz to 20 Hz	-	60	-	$\mu\text{G}/\sqrt{\text{Hz}}$ , rms
Frequency Property					
3 dB Bandwidth		-	167	-	Hz
TEMPERATURE SENSOR					
Scale Factor *1*2	Output = 2634(0x0A4A) @ +25 $^\circ\text{C}$	-	-0.0037918	-	$^\circ\text{C}/\text{LSB}$

\*1) This is a reference value used for internal temperature compensation. There is no guarantee that the value gives an absolute value of the internal temperature.

\*2) This is the temperature scale factor for the upper 16bit (TEMP\_HIGH).

\*3) Turn-on to turn-on / Day by day, estimated variation during 5 consecutive days.

Note) The values in the specifications are based on the data calibrated at the factory. The values may change according to the way the product is used.

Note) The Typ values in the specifications are average values or 1 $\sigma$  values.

Note) Unless otherwise noted, the Max / Min values in the specifications are design values or Max / Min values at the factory tests.

Table 2.4 Interface Specifications

$T_A=25\text{ }^\circ\text{C}$ ,  $V_{CC}=3.3\text{ V}$ , unless otherwise noted

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
<b>LOGIC INPUTS<sup>*1</sup></b>					
Positive Trigger Voltage	LVC MOS Schmitt	1.2	—	2.52	V
Negative Trigger Voltage	LVC MOS Schmitt	0.75	—	1.98	V
Hysteresis Voltage	LVC MOS Schmitt	0.3	—	—	V
Logic 1 Input Current, I <sub>INH</sub>	V <sub>IH</sub> = 3.3 V	—	0.1	—	μA
Logic 0 Input Current, I <sub>INL</sub>	V <sub>IL</sub> = 0 V	—	0.1	—	
Input Capacitance, C <sub>IN</sub>	—	—	8	—	pF
RST Voltage Range	—	0	—	V <sub>CC</sub> +0.3	V
RST High-level Input Voltage, V <sub>IH</sub>	—	0.8xV <sub>CC</sub>	—	—	V
RST Low-level Input Voltage, V <sub>IL</sub>	—	—	—	0.2xV <sub>CC</sub>	V
RST Low Pulse Width	—	100	—	—	ms
Pull-up Resistor	—	32	80	224	kΩ
<b>DIGITAL OUTPUTS<sup>*1</sup></b>					
Output High Voltage, V <sub>OH</sub>	I <sub>SOURCE</sub> =1.4mA LVC MOS	V <sub>CC</sub> -0.4	—	—	V
Output Low Voltage, V <sub>OL</sub>	I <sub>SINK</sub> =1.4mA LVC MOS	—	—	0.4	V
<b>FUNCTIONAL TIMES<sup>*3</sup></b>					
Time until data is available					
Power-On Start-Up Time	—	—	—	800	ms
Reset Recovery Time	—	—	—	800	ms
Flash Test Time	—	—	—	5	ms
Flash Backup Time	—	—	—	200	ms
Self Test Time	—	—	—	150	ms
Filter Setting Time	—	—	—	1	ms
DATA OUTPUT RATE	DOUT_RATE = 0x00	—	—	2000	Sps
Clock Accuracy	—	—	—	±0.001	%
<b>POWER SUPPLY</b>					
Operating voltage range, V <sub>CC</sub>					
Power Supply Current	—	3.15	3.3	3.45	V
	—	—	16	—	mA

\*1) Digital I/O signal pins operate at 3.3V inside the unit. All digital I/O signal pins (except RST) can tolerate 5V input.

\*2) This item is not included in the factory test items but its characteristic is confirmed.

\*3) These specifications do not include the effect of temperature fluctuation and response time of the internal filter.

## 2.4 Timing Specifications

Table 2.5 Timing Specification

$T_A=25\text{ }^\circ\text{C}$ ,  $V_{CC}=3.3\text{ V}$ , unless otherwise noted

Parameter	Description	Min.	Typ.	Max.	Unit
<b>NORMAL MODE</b>					
fSCLK		0.01		2.0	MHz
tSTALL	Stall period between data	20			$\mu\text{s}$
tWRITERATE	Write rate	40			$\mu\text{s}$
tREADRATE	Read rate	40			$\mu\text{s}$
<b>BURST MODE</b>					
fSCLK		0.01		1.0	MHz
tSTALL1	Stall period between data	45			$\mu\text{s}$
tSTALL2	Stall period between data	4			$\mu\text{s}$
tREADRATE2	Read rate	32			$\mu\text{s}$
<b>COMMON</b>					
tCS	Chip select to clock edge	10			ns
tDAV	SO valid after SCLK edge			80	ns
tDSU	SI setup time before SCLK rising edge	10			ns
tDHD	SI hold time after SCLK rising edge	10			ns
tSCLKR, tSCLKF	SCLK rise/fall times			20	ns
tDF, tDR	SO rise/fall times			20	ns
tSFS	High after SCLK edge CS	80			ns

Note) The specifications above are not included in the factory test items but their characteristic is confirmed.

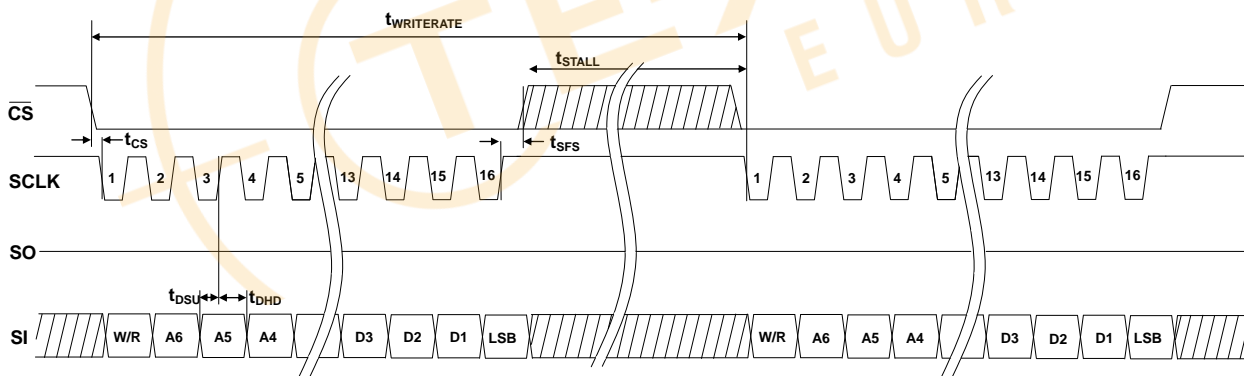


Figure 2.1 SPI Write Timing and Sequence

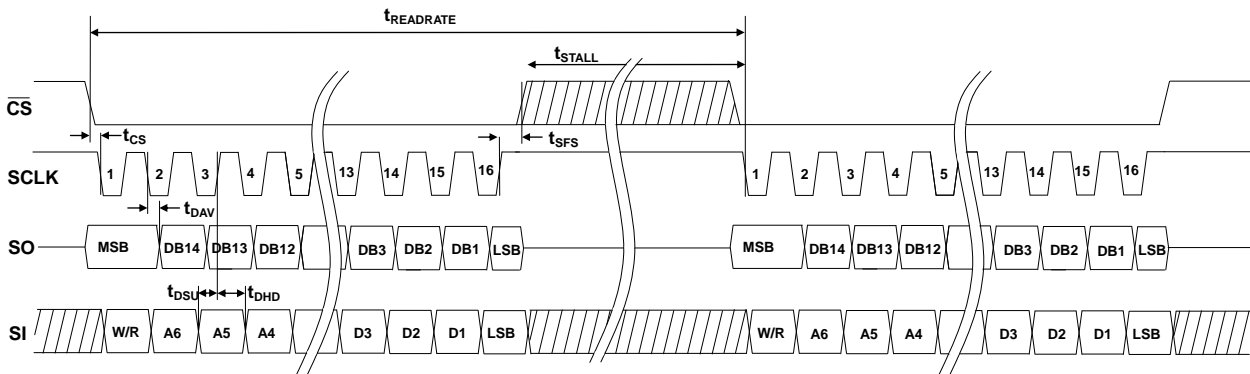


Figure 2.2 SPI Read Timing and Sequence

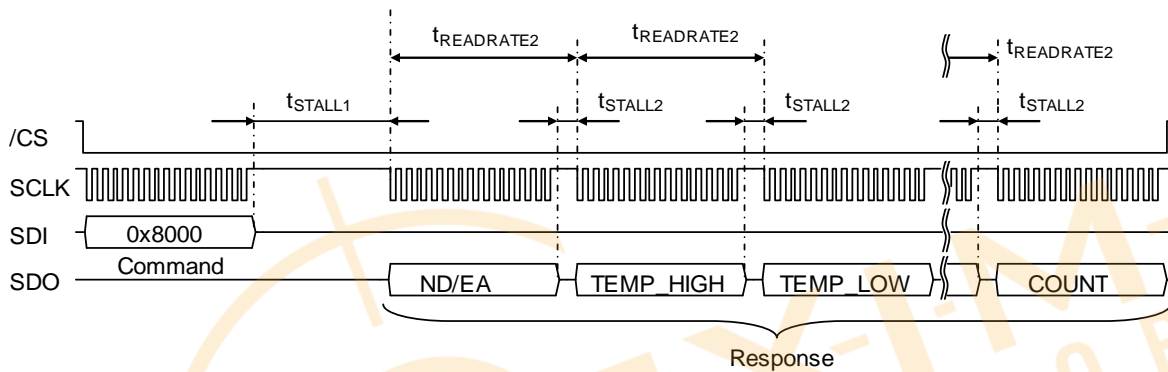


Figure 2.3 SPI Read Timing and Sequence (BURST MODE)

## 2.5 Connector Pin Layout and Functions

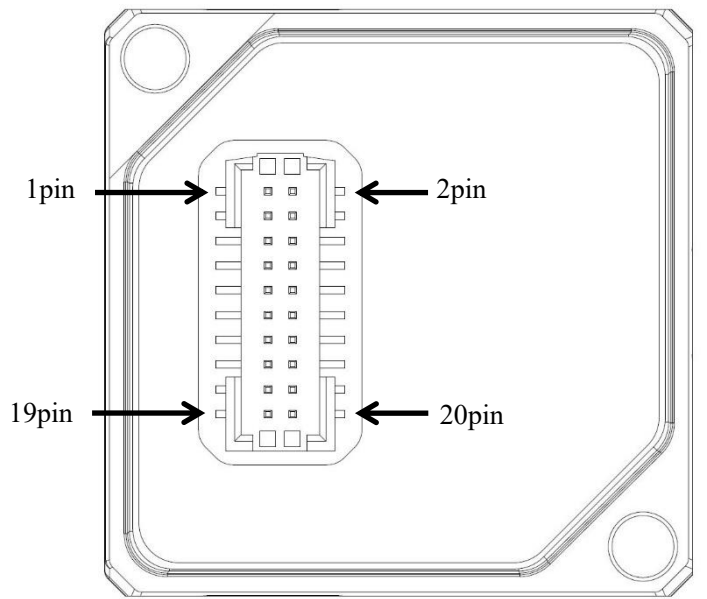


Figure 2.4 Connector Pin Assignment

Table 2.6 Pin Function Descriptions

Pin No.	Mnemonic	Type <sup>*1</sup>	Description
1	SCLK	I	SPI Serial Clock <sup>*2</sup>
2	SDO	O	SPI Data Output <sup>*2</sup>
5	SDI	I	SPI Data Input <sup>*2</sup>
6	/CS	I	SPI Chip Select <sup>*2</sup>
7	SOUT	O	UART Data Output <sup>*2</sup>
9	SIN	I	UART Data Input <sup>*2</sup>
13	DRDY (GPIO1)	I/O	Data Ready <sup>*3</sup> (General Purpose I/O1)
14	GPIO2 (EXT)	I/O	General Purpose I/O2 <sup>*4</sup> (External Trigger Input or External Counter Reset Input)
18	RTD	O	Run Time Diag Output <sup>*6</sup>
16	/RST	I	Reset <sup>*5</sup>
10,11,12	VCC	S	Power Supply 3.3V
3,4,8,15	GND	S	Ground
17,19,20	NC	N/A	Do Not Connect

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

\*2) Connect either SPI or UART but not both. Connecting both SPI and UART at the same time may result in malfunction of the device. Regarding unused pins, please connect unused input pins to VCC through resistor.

\*3) Regarding Pin function selection, please refer to the **DRDY\_ON** at register MSC\_CTRL[0x02(W1)],bit[2]

\*4) Regarding Pin function selection, please refer to the **EXT\_SEL** at register MSC\_CTRL[0x02(W1)],bit[7:6]

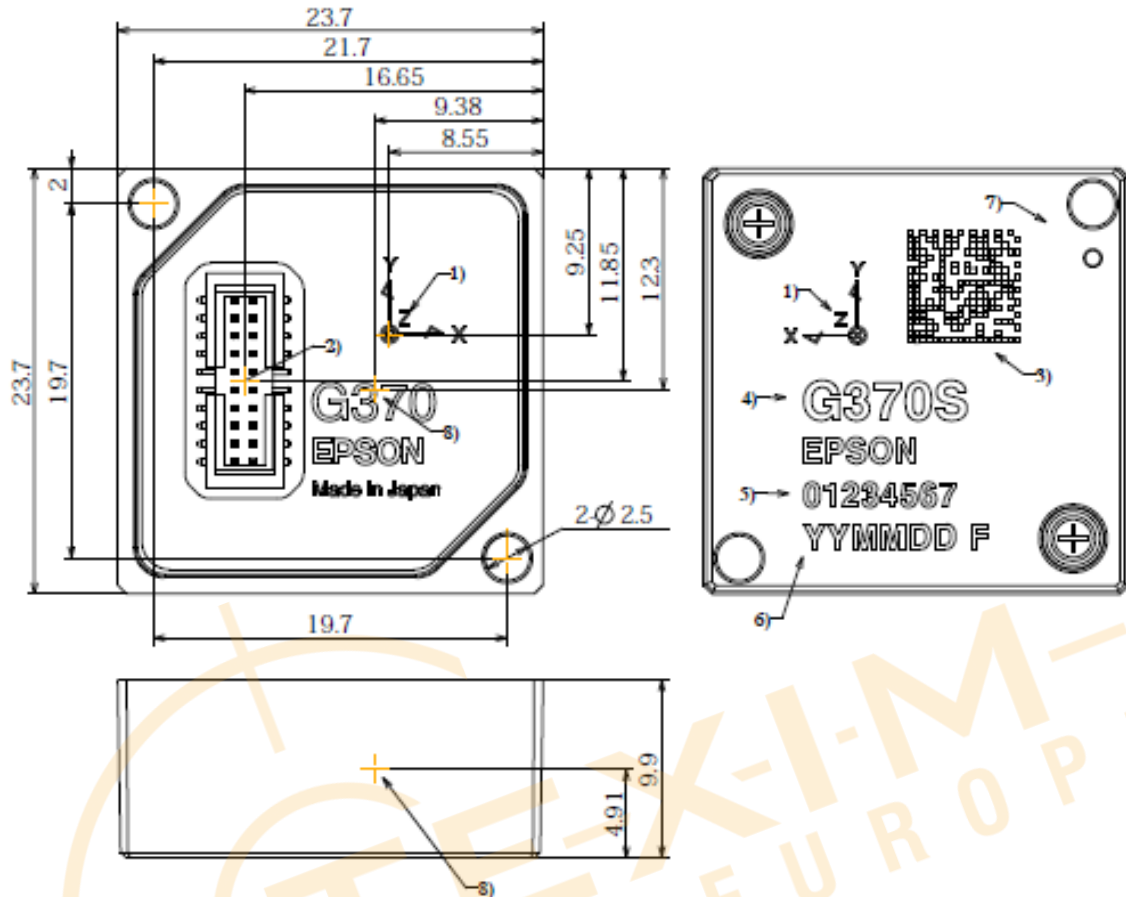
\*5) If the /RST pin is not used, keep the pin at High (Vcc) voltage level.

\*6) Regarding RTD (Run Time Diag Output) function, please refer to RT\_DIAG[0x2B(W0)]

Note) All input pins have weak pull up resistors inside the IMU.

### 3. Mechanical Dimensions

#### 3.1 Outline Dimensions



1)	Definition of sensor axes
2)	Connector Position
3)	Matrix code(Data Matrix) Including Product name & S/N & data & factory code
4)	Product Name
5)	Serial number
6)	data & factory code
7)	Frame ground
8)	Accelerometer origin

Figure 3.1 Outline Dimensions (millimeters)  
[ G370PDS0 ]

The right-hand screw rotation direction of the gyro sensor is positive (+).

### 3.2 Connector Dimensions

Figure 3.3 and Table 3.1 describes the connector manufacturer and the model number of the header built into the IMU.

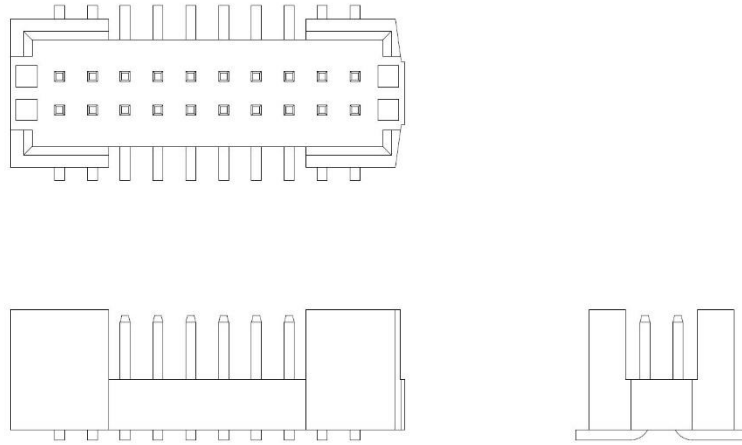


Figure 3.2 Header Pin Dimensions

Table 3.1 Header Part Number

Maker	Parts Number	RoHS Compliant
Samtec	FTMH-110-02-H-DV-ES	Yes

\* END SHROUDS is MOLDED TO POSITION END SHROUDS

Table 3.2 shows the connector manufacturer and the model number of the recommended socket used at the host side.

Table 3.2 Socket Part Number

Maker	Parts Number	RoHS Compliant
Samtec	CLM-110-02-H-D	Yes
Samtec	CLM-110-02-L-D	Yes

## 4. Typical Performance Characteristics

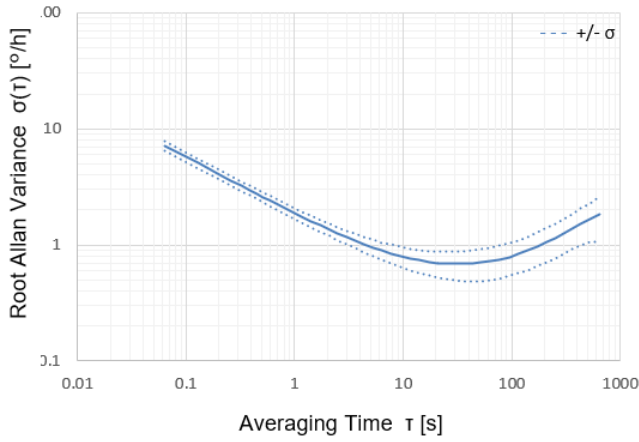


Figure 4.1 Gyro Allan Variance Characteristic

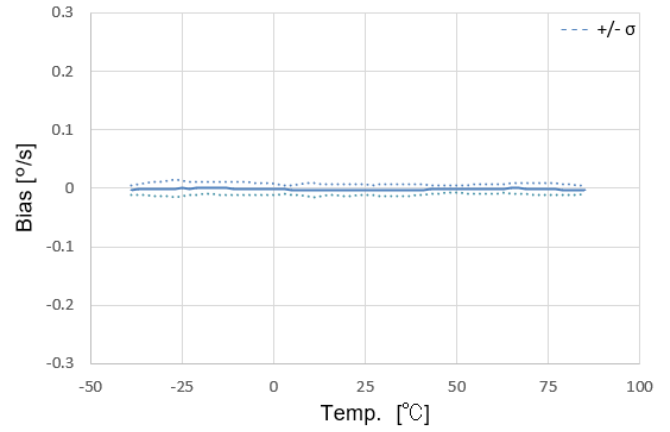


Figure 4.2 Gyro Bias vs. Temperature Characteristic

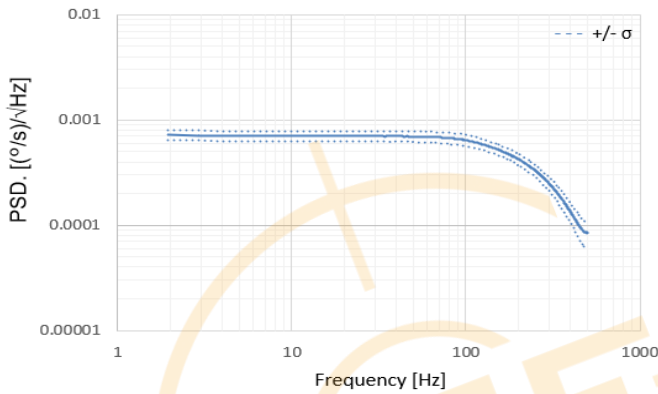


Figure 4.3 Gyro Noise Frequency Characteristic

The product characteristics shown above are just examples and are not guaranteed as specifications.

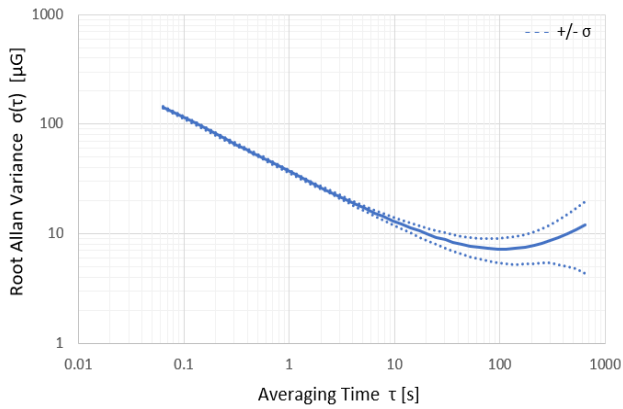


Figure 4.4 Accelerometer Allan Variance Characteristic

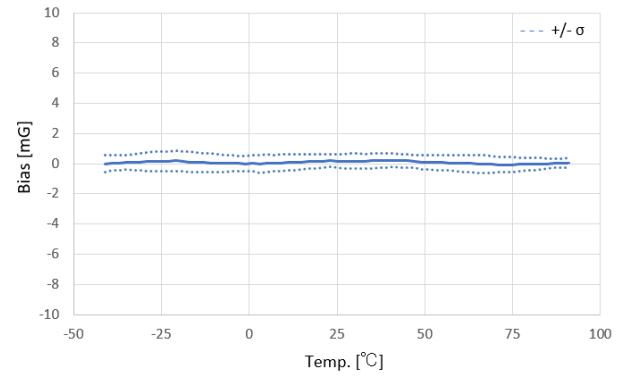


Figure 4.5 Accelerometer Bias vs. Temperature Characteristic

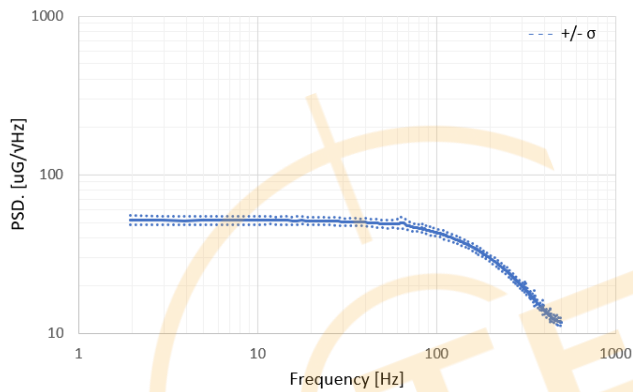


Figure 4.6 Accelerometer Noise Frequency Characteristic

The product characteristics shown above are just examples and are not guaranteed as specifications.

## 5. Basic Operation

### 5.1 Connection to Host

The device is connected to the host via SPI or UART. The following is an example of the connection.

NOTE: Connect either SPI or UART but not both. Connecting both SPI and UART at the same time may result in malfunction of the device.

NOTE: Refer to Table 2.6 Pin Function Description for the connection of unused pins.

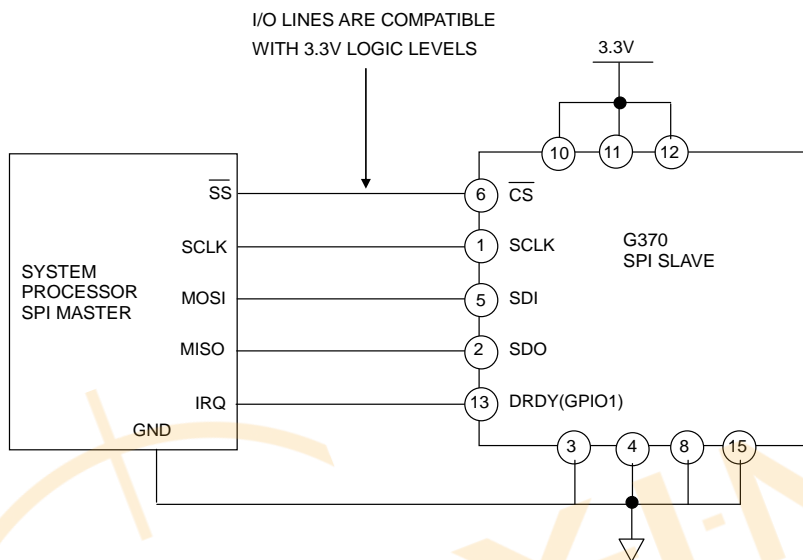


Figure 5.1 SPI Connection

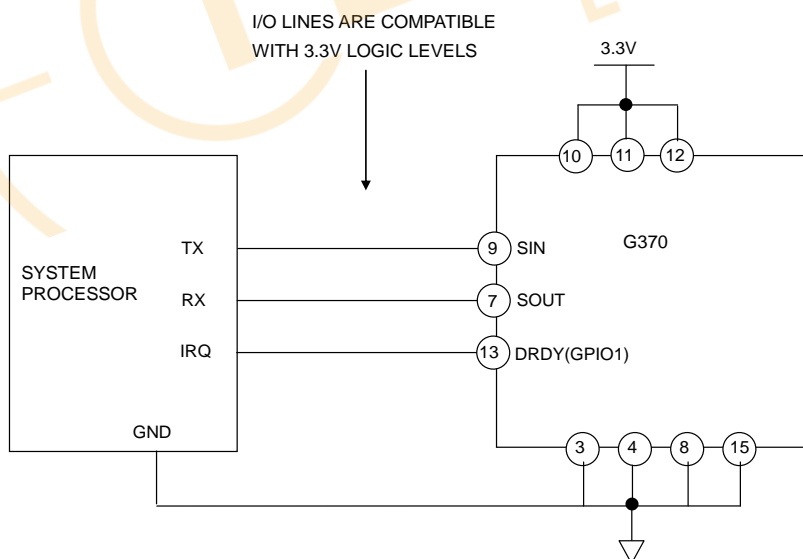


Figure 5.2 UART Connection

## 5.2 Operation Mode

The device has the following two operation modes. Only when UART is used, Sampling mode has two submodes: Manual mode and Auto mode.

- (1) Configuration mode
- (2) Sampling mode
  - Manual mode
  - Auto mode (for UART only)

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. Configure various operational settings in Configuration mode<sup>(\*1)</sup>. After configuration is completed, go to the sampling mode to read out the temperature, angular rate, and acceleration data. To change the operation mode, write to **MODE\_CMD** (MODE\_CTRL[0x02(W0)] bit[9:8]). When software reset is executed by writing 1 to **SOFT\_RST** (GLOB\_CMD[0x0A(W1)] bit[7]), internal initialization is executed and then the device goes into Configuration mode regardless of the current operation mode.

When the UART interface is used, writing to **UART\_AUTO** (UART\_CTRL[0x08(W1)] bit[0]) can switch between the Manual mode and the Auto mode<sup>(\*2)</sup>.

NOTE: When SPI interface is used, Manual mode must be selected. Otherwise, the device does not work properly.

\*1) 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 **GPIO\_DATA** (GPIO[0x08(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])

\*2) 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

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

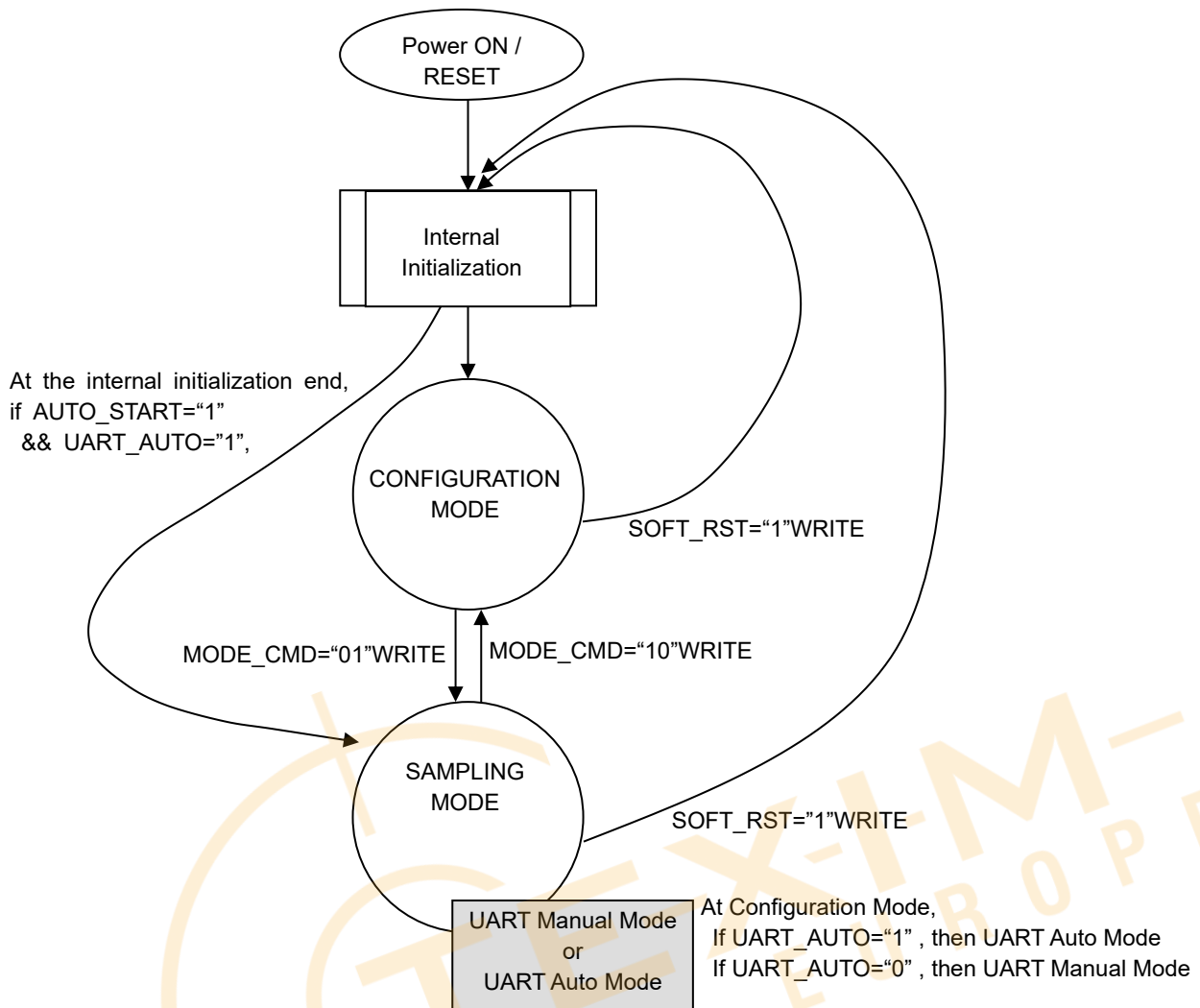


Figure 5.3 Operational State Diagram

### 5.3 Functional Block Diagram

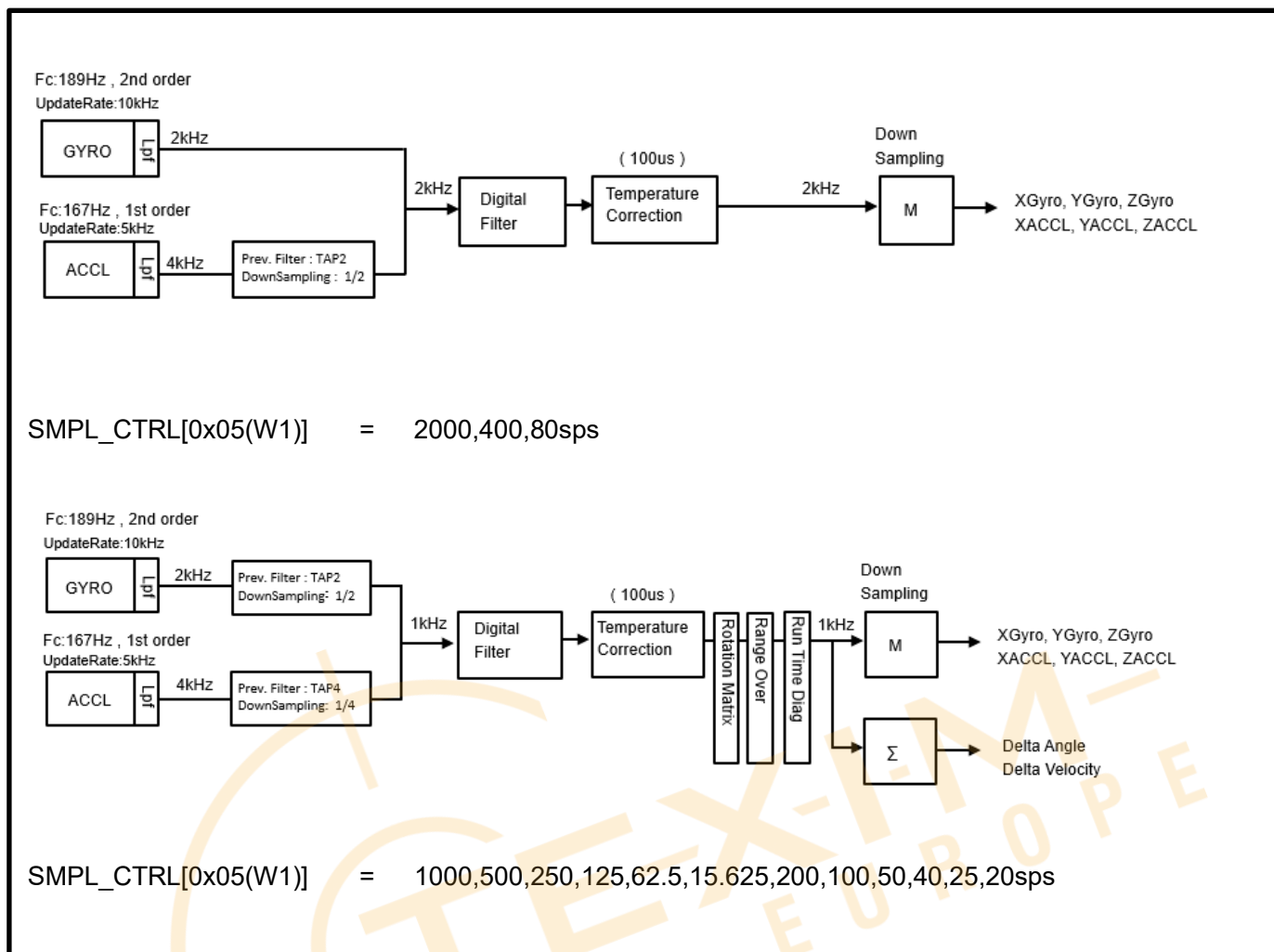


Figure 5.4 Functional Block Diagram

## 5.4 Data Output Timing

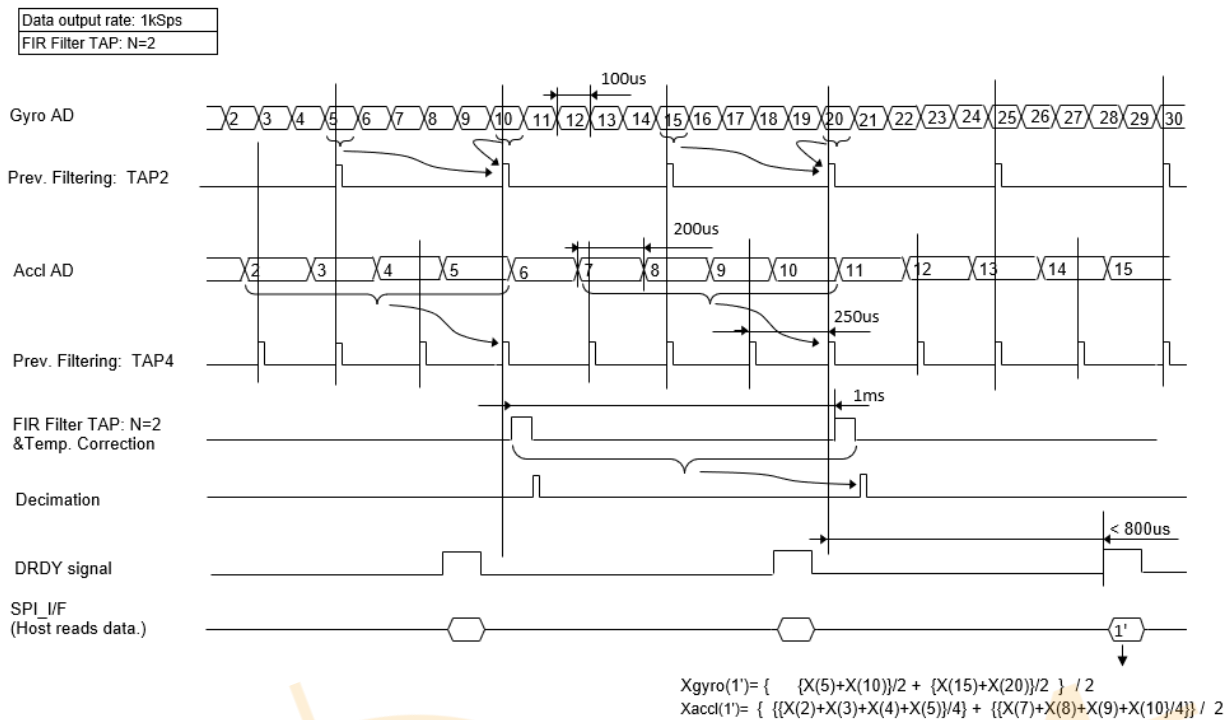


Figure 5.5 Data Output Timing – Data Output Rate 1kSps, FIR Filter TAP N=2

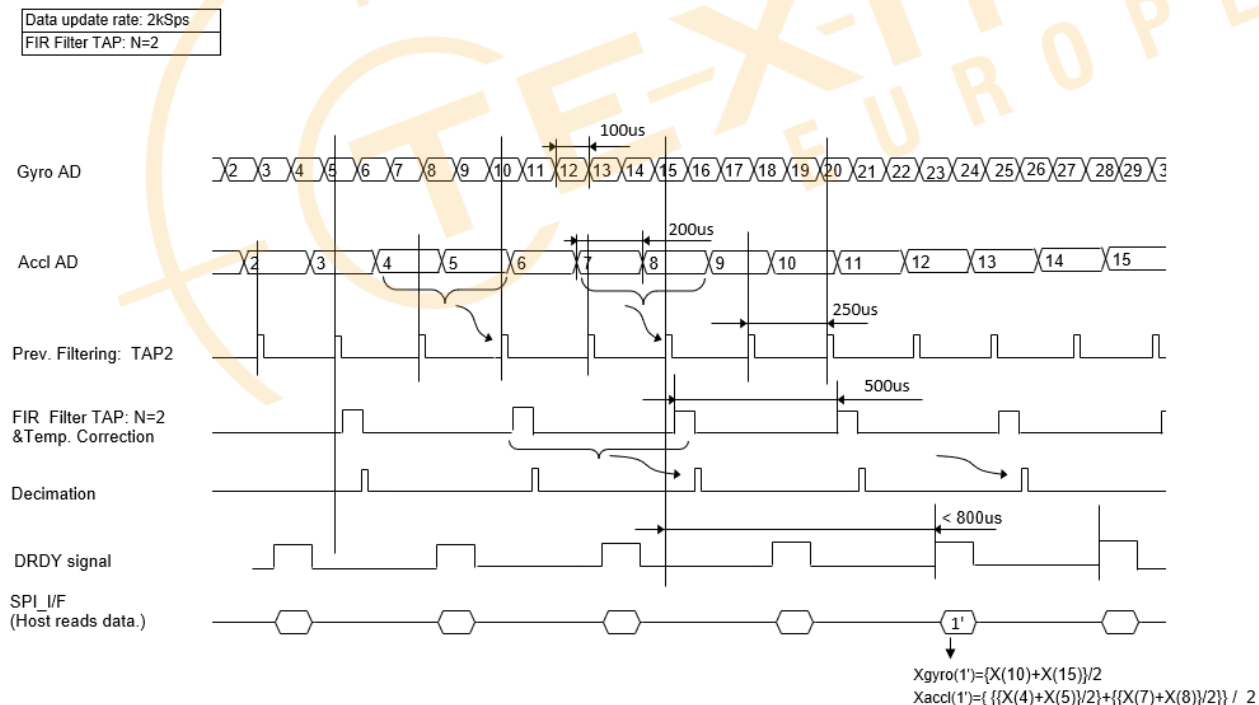


Figure 5.6 Data Output Timing – Data Output Rate 2000Sps, FIR Filter TAP N=2

NOTE: For Data Output Rate 2000sps/400sps/80sps, Digital Filter & Temp. Correction processing timing is 500us.

## 5.5 Data Ready Signal

The Data Ready signal is asserted when one sampling cycle completes and registers are updated with new sensor values. When the sensor values are read out, the Data Ready signal becomes negated. In case of UART AUTO mode, the Data Ready signal becomes negated just before data is output.

The Data Ready signal is output to the pin when the **DRDY\_ON** (MSC\_CTRL[0x02(W1)] bit[2]) is set to "1". The polarity of the signal can be changed by writing to the **DRDY\_POL** of MSC\_CTRL[0x02(W1)] bit[1] register.

The Data Ready signal is the logical sum of all the ND flags corresponding to each sensor value. If all the ND flags are disabled in the **ND\_EN** (SIG\_CTRL[0x00(W1)] bit[15:9][7:2]), the Data Ready will not be asserted. On the other hand, if all the sensor values enabled in the **ND\_EN** (SIG\_CTRL[0x00(W1)] bit[15:9]) are not read out, the Data Ready signal is kept asserted and never becomes negated.

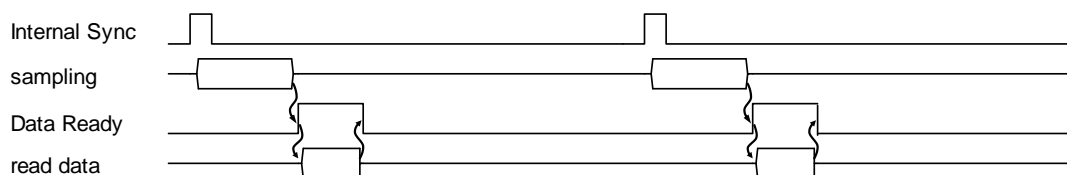


Figure 5.7 Data Ready Signal Timing

## 5.6 Sampling Counter

The count value based on the sampling timing of built-in AD converter can be acquired by reading COUNT[0x0A(W0)]. The timing accuracy is based on the internal reference oscillator (crystal).

The sampling count cycle interval depends on SMPL\_CTRL[0x05(W1)] as follows:

- SMPL\_CTRL[0x05(W1)] = 2000,400 and 80sps, the interval is 500 $\mu$ s/count.
- SMPL\_CTRL 0x05(W1) = 1000,500,250,125, 62.5, 15.625, 200,100, 50, 40, 25, and 20sps, the interval is 1000us/count.

Additionally, during UART/SPI burst mode and in UART Auto mode, the counter value can be included in the normal response by setting the **COUNT\_OUT** (BURST\_CTRL1[0x0C(W1)] bit[1]). For information about the response format, see 6.3 DATA PACKET FORMAT.

## 5.7 GPIO

The device has two general purpose I/O ports (GPIO). By accessing the GPIO[0x08(W0)] register, the direction (in/out) of each port can be configured and data can be read/written to. The GPIO port can be read in the normal mode, and also in the UART burst mode or UART auto mode.

GPIO1 is shared with the Data Ready signal. The switch between GPIO1 and Data Ready signal can be controlled by **DRDY\_ON** of MSC\_CTRL[0x02(W1)] bit[2] register. When **DRDY\_ON** is written as "0", GPIO1 act as general purpose I/O port.

GPIO2 is shared with EXT signal (External Trigger Input or External Counter Reset). The switch of GPIO2 and EXT signal can be controlled by **EXT\_SEL** of MSC\_CTRL[0x02(W1)] bit[7:6] register. When **EXT\_SEL** is written as "00", GPIO2 act as general purpose I/O port.

## 5.8 Self Test

The self test function can be used to check whether the outputs of the gyroscope and the accelerometer are within the pre-determined range and operating properly. For the gyroscope, the test result is OK if the bias of the output for each X-, Y-, or Z-axis is close to zero when the device is not moving. For the accelerometer, the test result is OK if the absolute value of the output as a three dimensional vector is equal to the gravitational acceleration. 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.

For information about the execution time of the self test, see “Self Test Time” in Table 2.4 Interface Specifications.

To use the self test function, see the description of the **SELF\_TEST** (MSC\_CTRL[0x02(W1)] bit[10]) and the **ST\_ERR\_ALL** (DIAG\_STAT[0x04(W0)] bit[1]).

## 5.9 External Trigger Input

External Trigger Input function provides control of the sample data output timing by using an externally supplied input pulse signal to GPIO2 (EXT) pin. By enabling the **EXT\_SEL** (MSC\_CTRL[0x02(W1)] bit[7:6]), GPIO2 pin can be used as External Trigger Input pin. The active polarity of External Trigger Input is positive pulse.

The external trigger input function can be selected with different timing characteristics from two types of TypeA and TypeB. TypeB is recommended for general use.

TypeA:

This can reduce the delay time from ADC completion of Gyro and Acceleration to external trigger input but only supports external input trigger frequency between 500 to 1000Hz.

TypeB (recommended):

This can increase the delay time compared to TypeA but supports a wider external trigger input frequency between 1 to 1000Hz.

Note) TypeA cannot be used in combination with DeltaAngle/DeltaVelocity (ATTI\_ON[0x15(W1)] bit [10:9] = “01”).

### ■ TypeA setting

To enable the TypeA External Trigger Input function, program the settings as shown below.

- Set EXT\_SEL to external trigger input by writing “10” to MSC\_CTRL[0x02(W1)] bit [7:6] -> enable TypeA external trigger input function \*1)
- Set FILTER\_SEL to moving average filter TAP=0 by writing “00000” to FILTER\_CTRL[0x06(W1)] bit [4:0]

\*1) By setting EXT\_SEL = “10”, A\_Lpf in Figure 5.10 is set to 16.7 Hz (order: 1st)

\*1) By setting EXT\_SEL = “10”, G\_Lpf in Figure 5.10 is set to 94.4 Hz (order: 2nd)

■ TypeB setting

To enable the TypeB External Trigger Input function, program the settings as shown below.

- Set DOUT\_RATE="0x00" -> 2000sps to SMPL\_CTRL[0x04(W1)],bit[15:8] \*1)
- Set EXT\_SEL to external trigger input by writing "11" to MSC\_CTRL[0x02(W1)] bit [7:6] -> enable TypeB external trigger input function
- When ATTI\_ON = 00, set FILTER\_SEL according to the input trigger frequency to FILTER\_CTRL[0x06(W1)] bit [4:0]. The valid FILTER\_SEL settings are described in Table 7.2 for a selected DOUT\_RATE. But in this case, instead of DOUT\_RATE frequency, use the input trigger frequency or lower to determine supported FILTER\_SEL settings.
- When ATTI\_ON = 01 (DeltaAngle/DeltaVelocity), the FILTER\_SEL can be set to TAP=0 or other values depending on the application.

\*1) When used in combination with DeltaAngle/ DeltaVelocity (ATTI\_ON[0x15(W1)] bit [10:9] = "01") and (see Table 5.2 TypeB external trigger input timing):

- For timing  $2\text{msec} \leq t_{ETC} \leq 10\text{msec}$ , please set SMPL\_CTRL[0x04 (W1)],bit[15:8] DOUT\_RATE="0x01" ->1000sps.
- For timing  $10\text{msec} \leq t_{ETC} \leq 1000\text{msec}$ , please set SMPL\_CTRL[0x04 (W1)],bit[15:8] DOUT\_RATE="0x00" ->2000sps.

Note) when External trigger Type B is used, RuntimeDIAG,Range Over Function and Frame Alignment Correction are not supported.

When this function is active, the operation is as follows:

- For UART Auto Mode:

In case of TypeA:

When External Trigger Input pin is asserted, FIR Filter & TempCorrection processing is performed immediately on the current Gyro and Accl sampling data and sent to Host automatically.

In case of TypeB:

FIR Filter & Temp Correction processing is performed at the internal rate timing for Gyro and Accl sampling data. When the external trigger input signal is asserted, the current sampling data after FIR Filter & Temp Correction processing is automatically sent to the host.

- For UART/SPI manual mode and SPI burst mode

In case of TypeA:

When External Trigger Input pin is asserted, FIR Filter & TempCorrection processing is performed immediately on the current Gyro and Accl sampling, updated in each register, and the Data Ready signal is asserted. The host should read the sampling data in synchronization with Data Ready.

In case of TypeB:

FIR Filter & Temp Correction processing is performed at the internal rate timing for Gyro and Accl sampling data. When the external trigger input signal is asserted, the current sampling data after FIR Filter & Temp Correction processing is updated in each register, and the Data Ready signal is asserted. The host should read the sampling data in synchronization with Data Ready.

The External Trigger Input timing requirements and diagrams are shown in Table 5.1, Table 5.2, Figure 5.8, Figure 5.9, Figure 5.10, and Figure 5.11.

Table 5.1 TypeA External Trigger Input Timing Requirements

Parameter	Description	Min	Max	Unit
$t_{ETW}$	External Trigger Input Width	100	-	nSec
$t_{ETC}$	External Trigger Input Cycle	1	2	mSec
$t_{ETA2T\_G}$	Time from Gyro ADC's completion to External Trigger Input (This is a precision of External Sync.)	0	100	$\mu$ s
$t_{ETA2T\_A}$	Time from Accl ADC's completion to External Trigger Input (This is a precision of External Sync.)	0	200	$\mu$ s
$t_{ETD1}^{*1}$	Delay time from External Trigger Input to DRDY asserted	-	800	$\mu$ s

\*1) This does not include group delay of the internal filter.

Table 5.2 TypeB External Trigger Input Timing Requirements

Parameter	Description	Min	Max	Unit
$t_{ETW}$	External Trigger Input Width	100	-	nSec
$t_{ETC}$	External Trigger Input Cycle	1 <sup>*2</sup>	1000	mSec
$t_{ETA2T\_G}$	Time from Gyro ADC's completion to External Trigger Input (This is a precision of External Sync.)	0	600 <sup>*3</sup>	$\mu$ s
$t_{ETA2T\_A}$	Time from Accl ADC's completion to External Trigger Input (This is a precision of External Sync.)	0	700 <sup>*3</sup>	$\mu$ s
$t_{ETD1}^{*1}$	Delay time from External Trigger Input to DRDY asserted	-	300	$\mu$ s

\*1) This does not include group delay of the internal filter.

\*2) When used together with DeltaAngle/ DeltaVelocity (ATTI\_ON[0x15(W1)] bit [10:9] = "01"),  
 $t_{ETC}$  Min=2mSec.

\*3) When using SMPL\_CTRL[0x04(W1)] bit[15:8] other than DOUT\_RATE="0x00" ->2000sps,  
 $t_{ETA2T\_G}$ = 1100us,  $t_{ETA2T\_A}$ = 1200us.

Data output rate: 1kSps
FIR Filter TAP: N=0

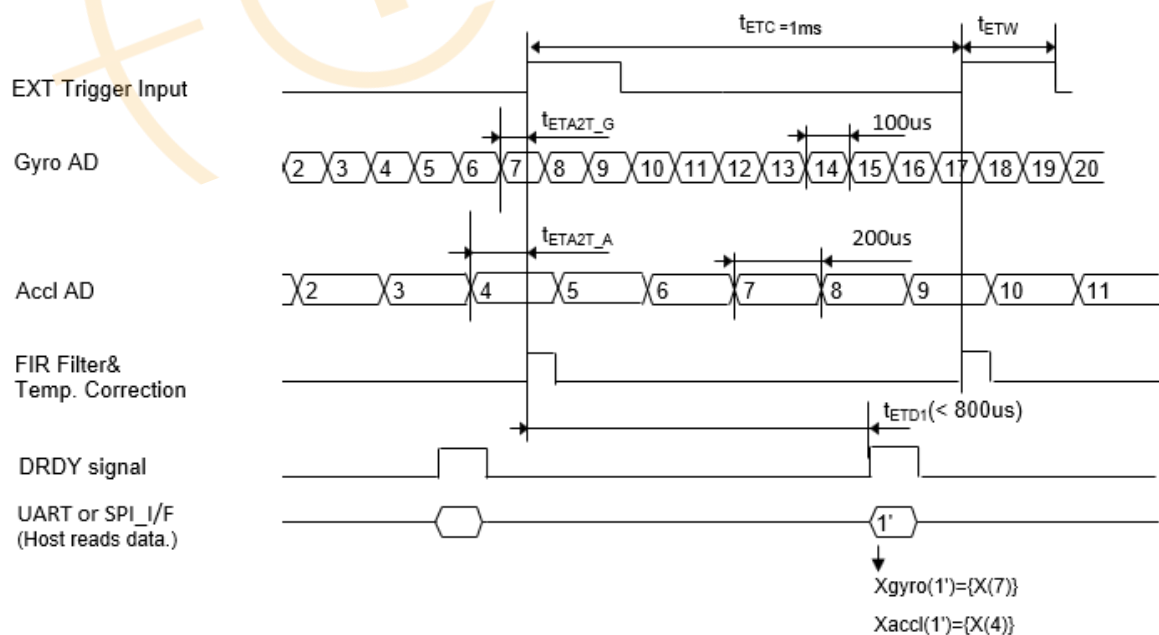


Figure 5.8 TypeA External Trigger Input (UART/SPI manual mode)

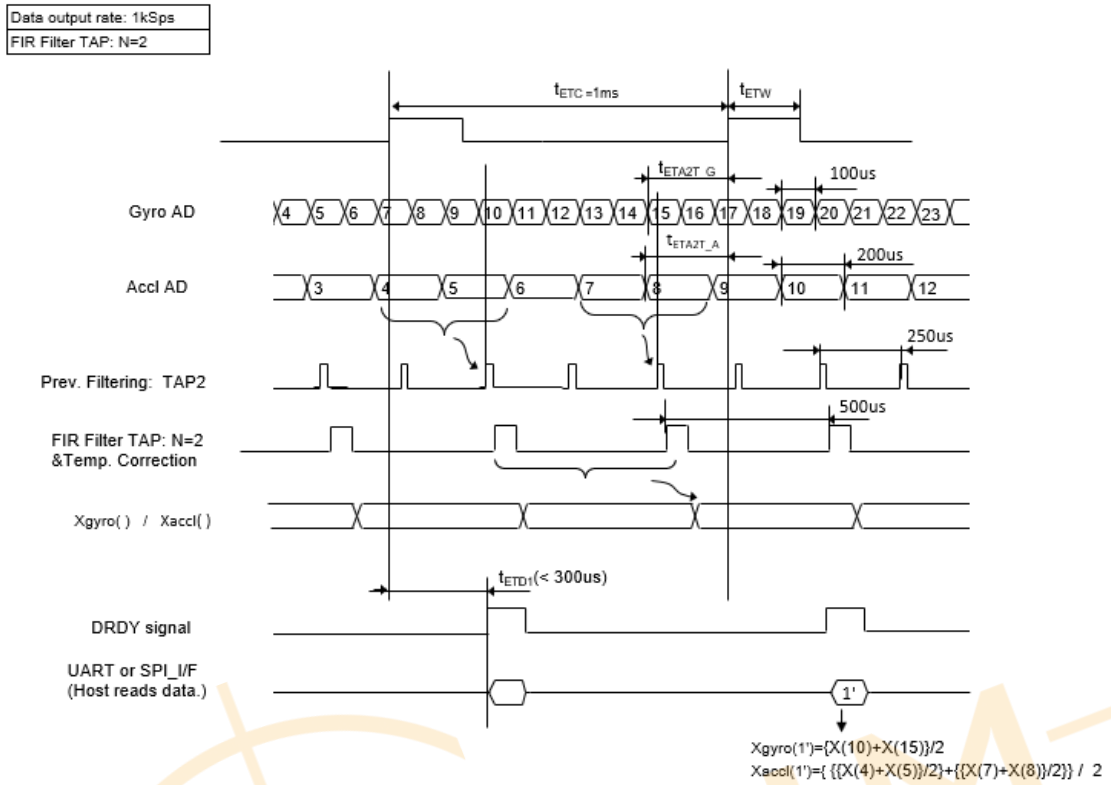


Figure 5.9 TypeB External Trigger Input (UART/SPI manual mode)

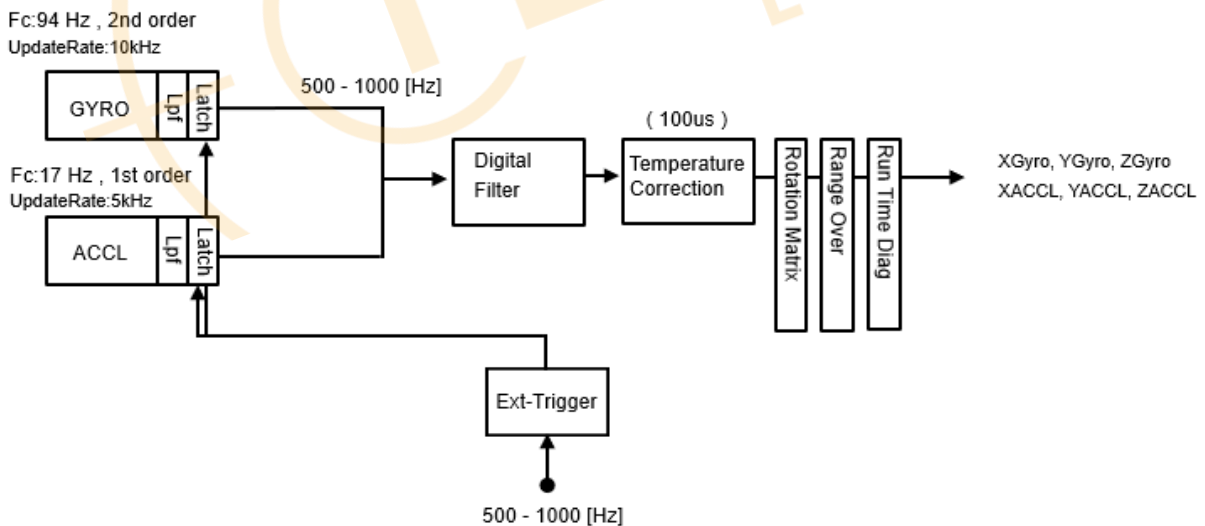


Figure 5.10 TypeA External Trigger input Functional Block Diagram

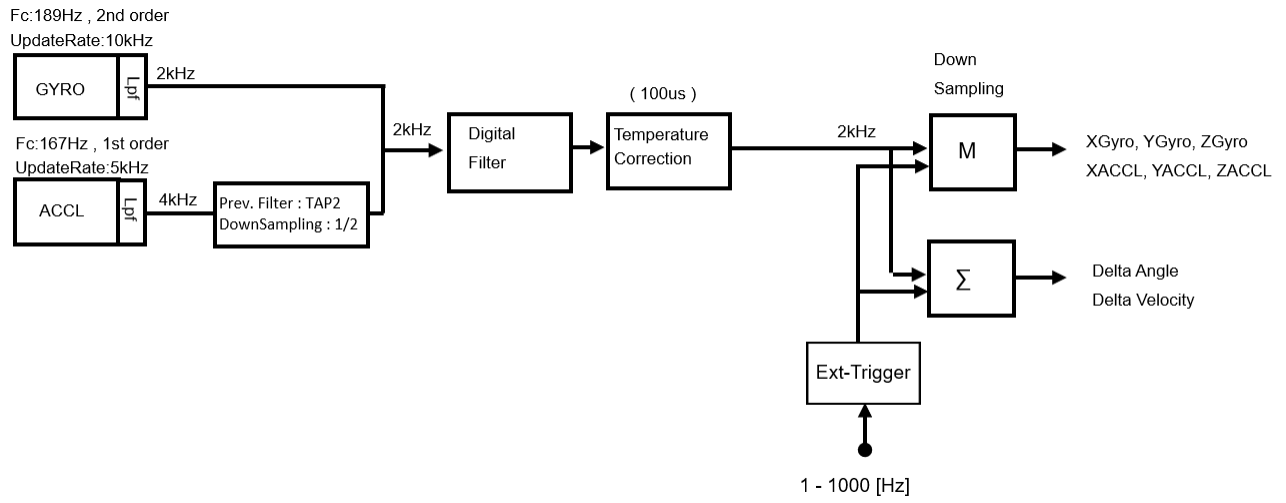


Figure 5.11 TypeB External Trigger input Functional Block Diagram



## 5.10 External Counter Reset Input

The External Counter Reset Input function can be used to measure the time offset from an externally supplied input trigger on GPIO2(EXT) pin to the completion of the next ADC sampling group.

This function is enabled by writing to **EXT\_SEL** (MSC\_CTRL [0x02(W1)] bit [7:6]) to select GPIO2 for use as an External Counter Reset Input terminal. The active polarity of the input signal is positive pulse.

The following describes the operation when this function is active:

- The IMU has an internal 16-bit up counter incrementing at 62.5kHz.
- The counter begins counting starting from 0 (\*1) when Sampling mode begins. The counting resolution is 16us.
- The counter can be reset by assertion of an external signal on the External Counter Reset Input terminal. After the counter is reset, the count value is cleared and begins incrementing again from 0.
- The counter value is transferred at the time of the ADC sampling completion and stored in COUNT [0x0A(W0)] register before the DataReady signal is asserted.
- The Host can obtain the time offset from External Counter Reset Input signal to ADC sampling completion time by reading the sampling data with the counter value when DataReady signal is asserted.
- The counter value is stopped (\*2) when Sampling mode is stopped.
- The counter will roll over and increment from 0 again, if the count value increments past 65535.

\*1) Enter Sampling mode from Configuration mode

\*2) Leave Sampling mode and enter Configuration mode

NOTE: When the External Counter Reset Input function is enabled, the COUNT [0x0A(W0)] register stores the counter value instead of the sampling count.

The timing specification and timing diagram for the External Counter Reset Input function is shown in Table 5.2 and Figure 5.12.

Table 5.2 External Counter Reset Input Timing

Parameter	Description	Min	Max	Unit
$t_{ERW}$	External Reset Input Width	100	-	nSec
$t_{ERC}$	External Reset Input Cycle	1	1000	mSec
$t_{ER2A}$	Time from External Reset Input to ADC completion	$(\text{count}^{*1} \times 16) + \Delta_{ER2A}$		Ms
$\Delta_{ER2A}$	Precision of $t_{ER2A}$	-150	150	Ms

\*1) The count value is read from register COUNT [0x0A(W0)] as indicated.

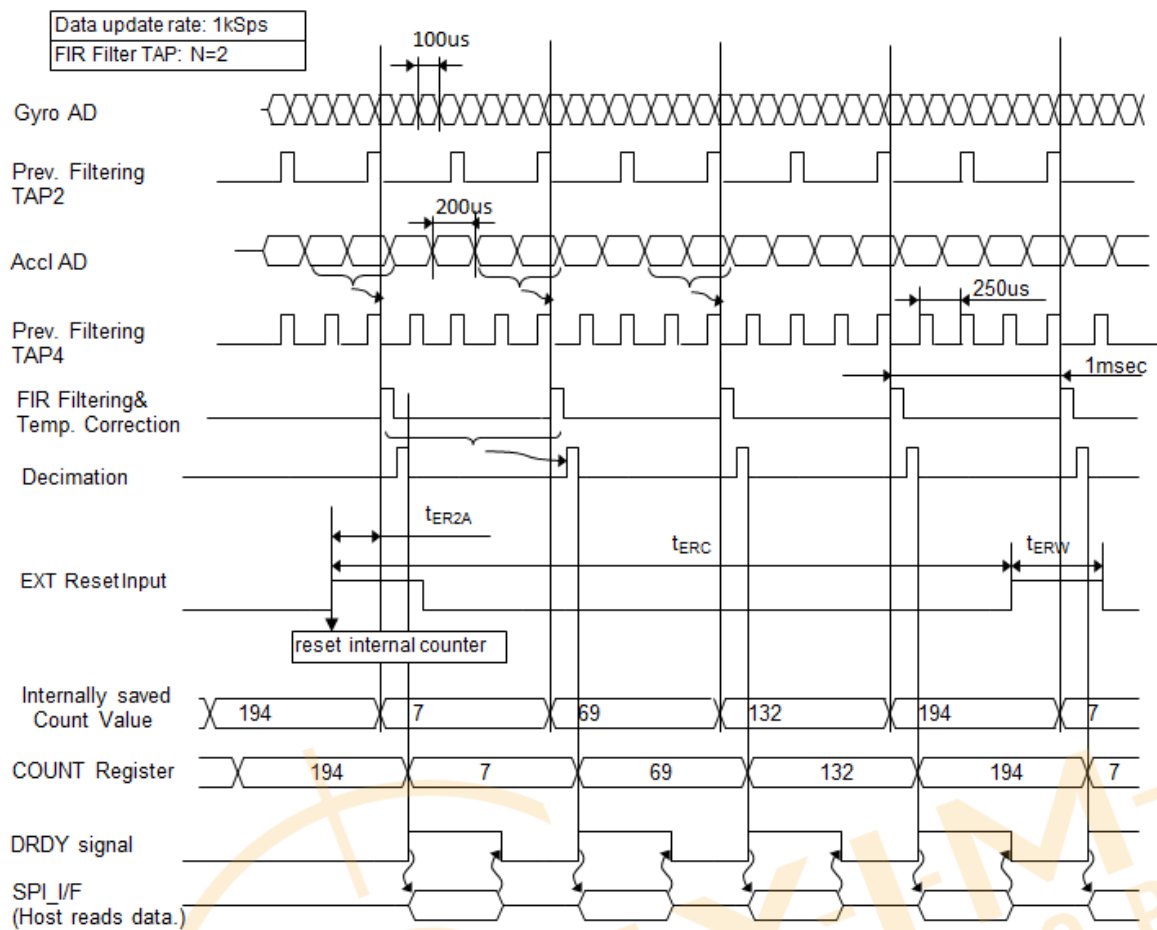


Figure 5.12 External Counter Reset Input

## 5.11 Checksum

A checksum can be appended to the response data during UART/SPI Burst mode or UART Auto mode by enabling this function in **CHKSM\_OUT** (BURST\_CTRL1 [0x0C(W1)] bit 0).

The checksum range of the data content is calculated immediately after the address byte (0x80) of the response data up to (not including) the delimiter byte (CR=0x0D). The calculation method of checksum is 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 total is "611B4" for the following response data stream, the checksum is "11B4":

"FE01 C455 4000 0052 33C0 0043 7BC8 004A 2608 FD73 3AA0 FF75 4C30 1F53 8FD0 0600 0014"

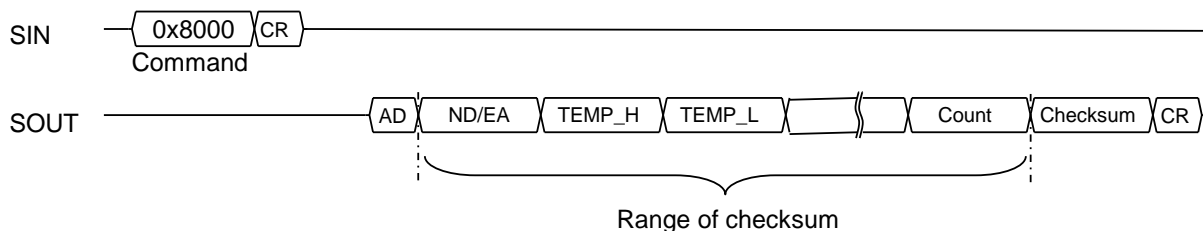


Figure 5.13 Checksum

## 5.12 Automatic Start (For UART Auto Mode Only)

The Automatic Start function when enabled allows the device to automatically enter Sampling Mode after completing internal initialization when power is supplied or the IMU is reset. This function is designed to be used in conjunction with the UART Auto Mode. Please refer to Figure 5.3 for the state transition.

Follow the procedures below to enable the Automatic Start function:

1. Write a "1" to both **UART\_AUTO** (bit 0) and **AUTO\_START** (bit 1) of **UART\_CTRL** [0x08(W1)].
2. 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).
3. The IMU will automatically enter Sampling Mode after the power supply is cycled, or a hardware reset, or a software reset command is executed.

The Automatic Start function can be enabled simultaneously with the External Trigger Input function.

Follow the procedures below to enable the Automatic Start with External Trigger Input function:

1. Write a "1" to both **UART\_AUTO** (bit 0) and **AUTO\_START** (bit 1) of **UART\_CTRL** [0x08(W1)].
2. Write a "10" to **EXT\_SEL** (MSC\_CTRL [0x02(W1)] bit [7:6]) to enable the External Trigger Input. Please connect the external trigger input signal to the GPIO2 pin.
3. 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).
4. The IMU will automatically enter Sampling Mode after the power supply is cycled, or a hardware reset, or a software reset command is executed.

## 5.13 Filter

This device contains built-in user configurable digital filters that are applied to the sensor data. The type of filter (moving average filter or FIR Kaiser filter) and the numbers of TAPs can be set with the **FILTER\_CTRL** [0x06(W1)] register. Figure 5.14, Figure 5.15, and Figure 5.16 are the typical characteristics of **SMPL\_CTRL**[0x05(W1)] = 2000sps, 400sps and 80sps.

(1) Moving Average Filter:

TAP setting can be N= 2, 4, 8, 16, 32, 64, or 128.

Figure 5.14 shows the characteristics of this filter.

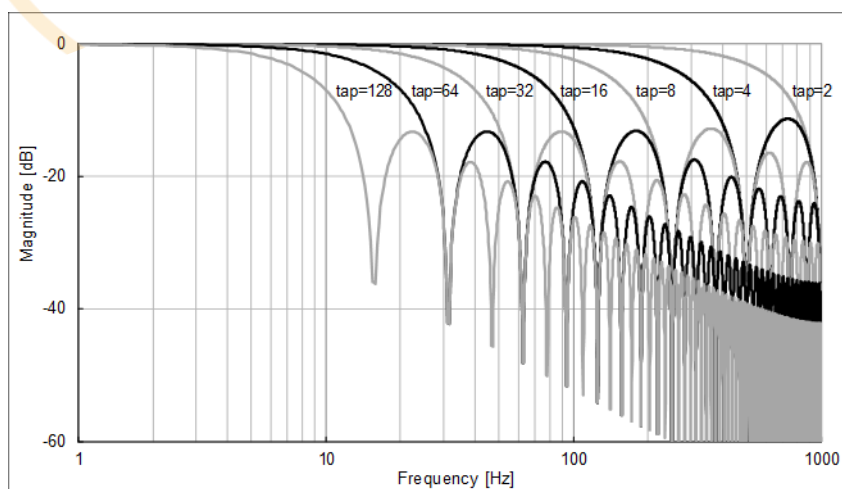


Figure 5.14 Moving Average Filter Characteristics

(2) FIR Kaiser filter:

Uses Kaiser Window(parameter=8)

TAP setting can be N= 32, 64, or 128 with cutoff frequency  $f_c = 50, 100, 200,$  or  $400\text{Hz}$ .

Figures 5.15 and 5.16 show the typical characteristic of this filter.

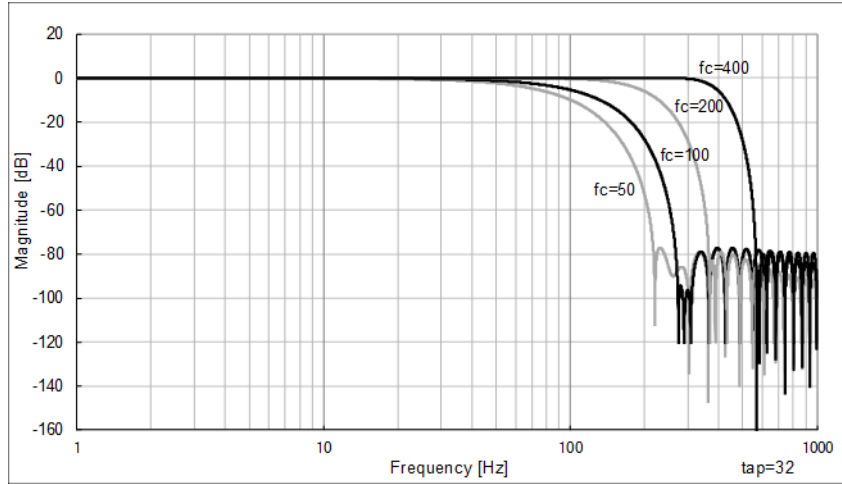


Figure 5.15 FIR Kaiser Filter Typical Characteristic 1

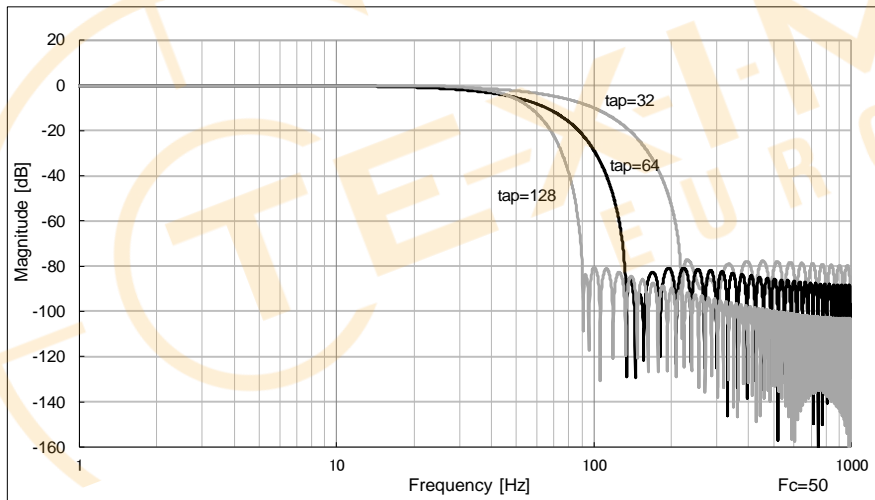


Figure 5.16 FIR Kaiser Filter Typical Characteristic 2

Figure 5.17, Figure 5.18, and Figure 5.19 are the typical characteristics of SMPL\_CTRL[0x05(W1)] = 1000sps,500sps,250sps,125sps,62.5sps,31.25sps,15.625sps,200sps,100sps,50sps,40sps and 25 sps.

(1) Moving Average Filter:

TAP setting can be N= 2, 4, 8, 16, 32, 64, or 128.

Figure 5.17 shows the characteristics of this filter.

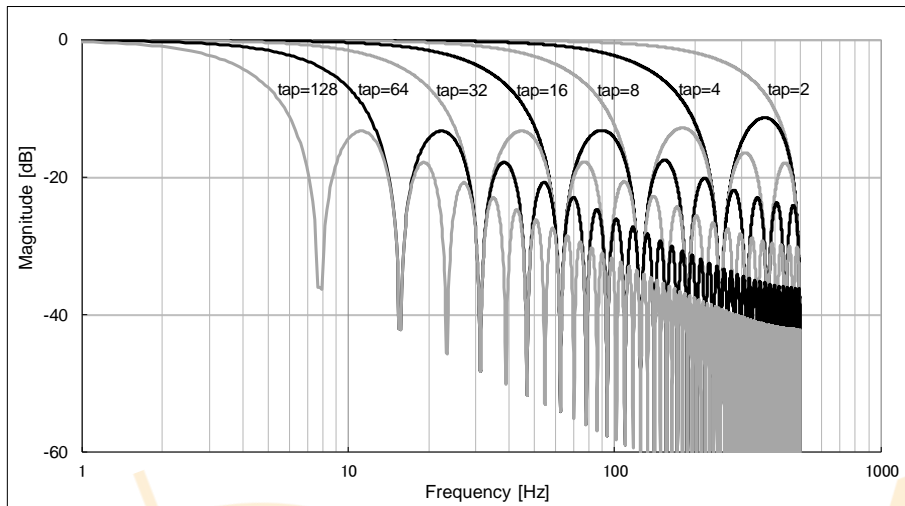


Figure 5.17 Moving Average Filter Characteristics

(2) FIR Kaiser filter:

Uses Kaiser Window(parameter=8)

TAP setting can be N= 32, 64, or 128 with cutoff frequency  $f_c$ = 25, 50, 100, or 200Hz.

Figures 5.18 and 5.19 show the typical characteristic of this filter.

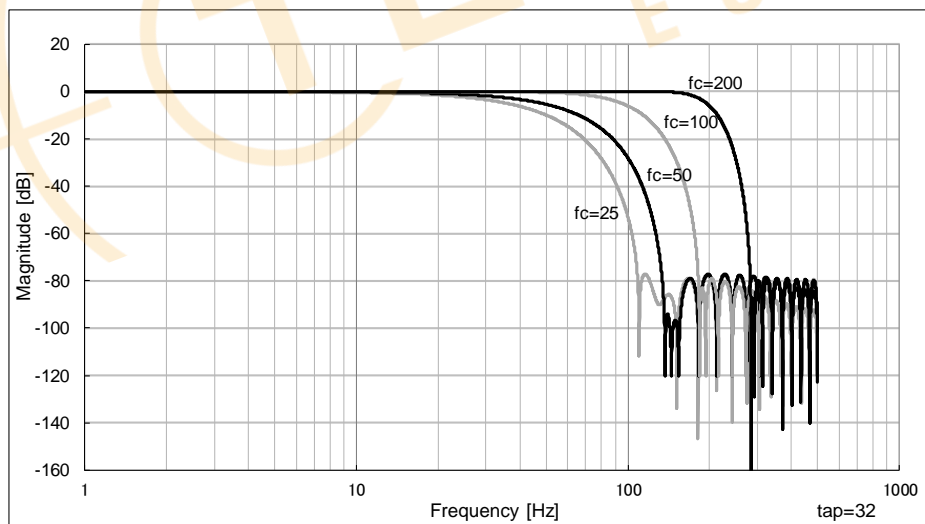


Figure 5.18 FIR Kaiser Filter Typical Characteristic 1

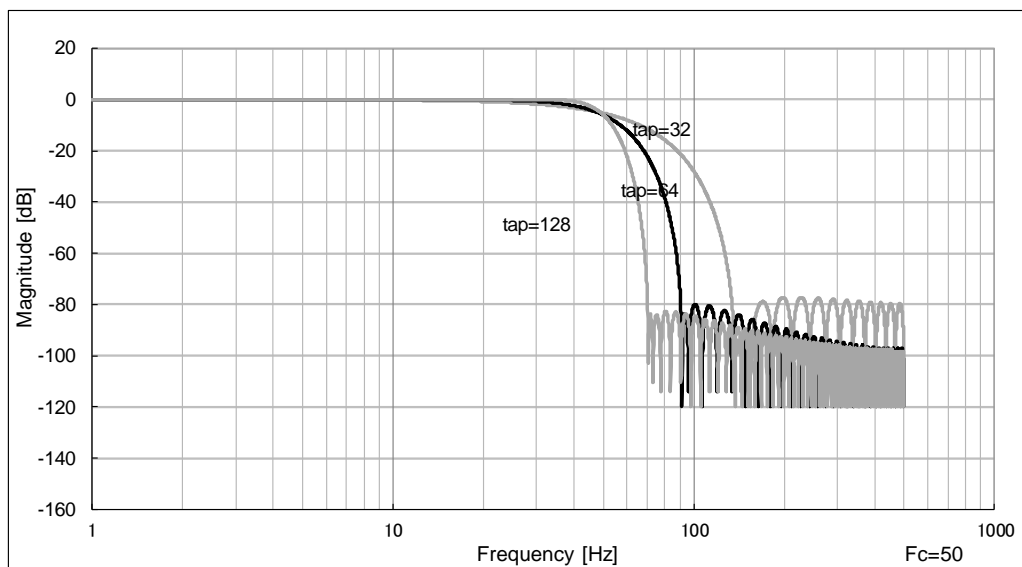


Figure 5.19 FIR Kaiser Filter Typical Characteristic 2



Please note that the transient response of the digital filter is a maximum of 127 samples from the sampling start time and varies depending on the output data rate and the filter tap setting. Refer to Table 5.3 which describes the transient response in terms of number of samples for valid combinations of output data rate and filter tap setting.

Table 5.3 Transient Response in Number of Samples Based on Output Data Rate vs Filter Tap

	TAP0	TAP2	TAP4	TAP8	TAP16	TAP32	TAP64	TAP128
2000sps	0	1	3	7	15	31	63	127
1000sps	0	1	3	7	15	31	63	127
500sps	/	0	1	3	7	15	31	63
400sps	/	/	/	1	3	6	12	25
250sps	/	/	0	1	3	7	15	31
200sps	/	/	/	1	3	6	12	25
125sps	/	/	/	0	1	3	7	15
100sps	/	/	/	/	1	3	6	12
80sps	/	/	/	/	/	1	2	5
62.5sps	/	/	/	/	0	1	3	7
50sps	/	/	/	/	/	1	3	6
40sps	/	/	/	/	/	1	2	5
31.25sps	/	/	/	/	/	0	1	3
25sps	/	/	/	/	/	/	1	3
20sps	/	/	/	/	/	/	1	2
15.625sps	/	/	/	/	/	/	0	1

	TAP32 Fc50	TAP32 Fc100	TAP32 Fc200	TAP32 Fc400	TAP64 Fc50	TAP64 Fc100	TAP64 Fc200	TAP64 Fc400
2000sps	31	31	31	31	63	63	63	63
1000sps	31	31	31	31	63	63	63	63
500sps	15	15	15	/	31	31	31	/
400sps	6	6	6	/	12	12	12	/
250sps	7	7	/	/	15	15	/	/
200sps	6	6	/	/	12	12	/	/
125sps	3	/	/	/	7	/	/	/
100sps	3	/	/	/	6	/	/	/
80sps	/	/	/	/	/	/	/	/
62.5sps	/	/	/	/	/	/	/	/
50sps	/	/	/	/	/	/	/	/
40sps	/	/	/	/	/	/	/	/
31.25sps	/	/	/	/	/	/	/	/
25sps	/	/	/	/	/	/	/	/
20sps	/	/	/	/	/	/	/	/
15.625sps	/	/	/	/	/	/	/	/

	TAP128 Fc50	TAP128 Fc100	TAP128 Fc200	TAP128 Fc400
2000sps	127	127	127	127
1000sps	127	127	127	127
500sps	63	63	63	
400sps	25	25	25	
250sps	31	31		
200sps	25	25		
125sps	15			
100sps	12			
80sps				
62.5sps				
50sps				
40sps				
31.25sps				
25sps				
20sps				
15.625sps				



## 5.14 Delta Angle/Delta Velocity Output

Delta-Angle/Delta-Velocity Output is the function to output integrated angle increments and integrated velocity increments by mathematical accumulation of the angular rate and linear acceleration sensor values.

Delta Angle Register and Delta Velocity Register [0x64~0x7B (W0)] represents the 32-bit numerical integration of angular rate and linear acceleration value before the down-sampling block. The integration of angular rate and linear acceleration value is reset when the Host reads the Delta Angle Register and Delta Velocity Register or automatically in UART Auto mode after sending the data output.

For example, in case of down-sampling ratio 4:1 (DOUT\_RATE of SMPL\_CTRL[0x05 (W1)] = 0x03), the integration data of four x-axis angular rate and x-axis linear acceleration values after filtering and temperature correction is stored in XDLTA\_HIGH, XDLTA\_LOW (Register[0x64~0x67 (W0)]) and XDLTV\_HIGH, XDLTV\_LOW (Register[0x70~0x73 (W0)]) respectively in 32bit data format. Figure 5.16 shows the timing diagram in the case of down-sampling ratio 4:1, 250sps and FilterTAP: N=4.

- Point A: By reading XDLTA\_HIGH, XDLTA\_LOW by Host at point A' (4ms before point A), the integration of angular rate and acceleration value is reset to 0.
- Point B: "55" is output after integration of values 15, 20, 25, -5.

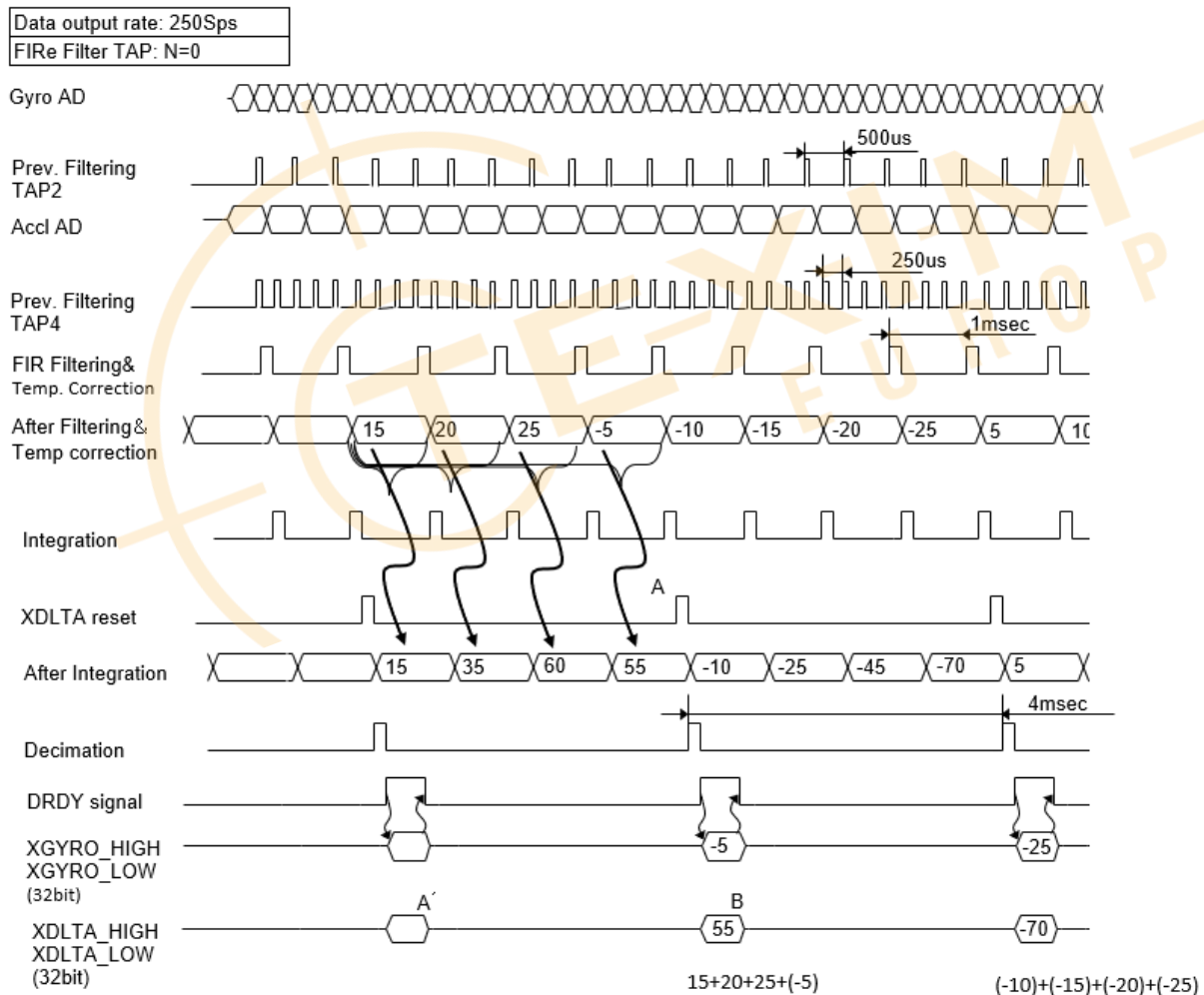


Figure 5.17 Delta Angle/Delta Velocity

As described above, the numerical integration of angular rate and linear acceleration values is reset by reading Delta Angle Register and Delta Velocity Register by Host or automatically in UART Auto mode after sending the data output. However when selecting 16bit output mode in **DLTA\_BIT** of BURST\_CTRL2[0x0E(W1)] bit 11 or **DLTV\_BIT** of BURST\_CTRL2[0x0E(W1)] bit 10, the upper 16bit of the value will be output and lower 16bit will be added to the next integration cycle.

NOTE: Delta Angle/Delta Velocity output is restricted and not supported for SPI normal mode reads.

NOTE: DeltaAngle/DeltaVelocity cannot be used in combination with External Trigger Input, TypeA (MSC\_CTRL[0x02(W1)],bit[7:6]="10")

NOTE: Delta Angle and Gyro sensor output cannot be used together, and Delta Velocity and Accelerometer sensor cannot be used together.

NOTE: when Delta Angle / Delta Velocity is enabled, the FILTER\_SEL can be set to TAP=0 (or other value regardless of DOUT\_RATE setting)

To enable Delta Angle/Delta Velocity output, program the settings as shown below.

1. Enable burst data output by writing "1" to DLTA\_OUT or DLTV\_OUT of BURST\_CTRL1 [0x0D (W1)] bit [11:10].
2. Set the required bit length for DLTA\_BIT or DLTV\_BIT in BURST\_CTRL2 [0x0F (W1)] bits [11:10]
3. Set the required scale factor for DeltaAngle and/or DeltaVelocity, respectively in DLTA\_RANGE\_CTRL or DLTV\_RANGE\_CTRL of DLT\_CTRL[0x12(W1)] bit[7:4] & bit[3:0].

NOTE: By setting an appropriate scale factor, overflow due to accumulation of angular velocity and acceleration values can be avoided. The appropriate scale factor depends on the operating conditions of the application.

4. Write "01" to ATTI\_ON of ATTI\_CTRL [0x15 (W1)], bits [10:9] to enable the delta angle/delta velocity output function. Section 6.3 provides an example of the DeltaAngle / DeltaVelocity output data fields for burst output in data packet format.

## 5.15 Range Over Function

This device supports the notification when a range over condition is detected in the sensor data. The range over detection threshold is equal to the dynamic range for both the Gyro sensor and the Accelerometer sensor described in 2.3 Characteristics and Electrical specifications.

G370PDS0 Dynamic Range

Gyro Sensor :  $\pm 200$ [deg/s]

Accelerometer :  $\pm 10$ [G]

Detection is performed by "RangeOver" block in the processing order as described in Figure 5.4 Functional Block Diagram.

The host can confirm that a range over has occurred by reading the RO bit of FLAG(ND/EA) in the burst read data or the register FLAG[0x06(W0)] bit[8]. The source of the range over occurrence can be confirmed by reading RANGEOVER[0x0C(W0)]bit[13:8] bit[0].

The RO bits of RANGEOVER[0x0C(W0)]bit[13:8],bit[0] are reset by reading the register, so that any subsequent range over detection can be resumed during sampling.

Refer to FLAG[0x06(W0)], RANGEOVER[0x0C(W0)] for register operation.

Note) The range over function is not supported when SMPL\_CTRL[0x05(W1)] = 2000,400,80sps

Note) when External trigger Type B is used, Range Over Function is not supported.

## 5.16 Frame Alignment Correction

The frame alignment of the three-axis gyro triad and accelerometer triad can be independently corrected by using the R\_MATRIX function. The matrix coefficients are 16-bit fixed-point numbers with 2 bits representing the integer part including the sign bit, and 14 bits representing the fractional part. The default coefficient values for the R\_MATRIX, if unchanged, will result in an identity matrix.

- R\_MATRIX\_G\_M\*\* ,REG[0x38 ~ 0x49 (W1)]: The coefficients for the 3x3 rotation matrix for gyro triad.
- R\_MATRIX\_A\_M\*\* ,REG[0x4A ~ 0x5B (W1)]: The coefficients for the 3x3 rotation matrix for accelerometer triad.

Frame alignment correction of the gyroscope triad is represented by the 3x3 matrix multiplication operation:

$$\begin{bmatrix} Gx \\ Gy \\ Gz \end{bmatrix} = \begin{bmatrix} R\_MATRIX\_G\_M11 & R\_MATRIX\_G\_M12 & R\_MATRIX\_G\_M13 \\ R\_MATRIX\_G\_M21 & R\_MATRIX\_G\_M22 & R\_MATRIX\_G\_M23 \\ R\_MATRIX\_G\_M31 & R\_MATRIX\_G\_M32 & R\_MATRIX\_G\_M33 \end{bmatrix} \begin{bmatrix} gx \\ gy \\ gz \end{bmatrix}$$

G: Gyroscope output data after the rotation matrix operation.

The output is X, Y, and Z of GYRO registers (REG[0x12 ~ 0x1D (W0)]).

M: Misalignment 3x3 matrix

g: Measurement data (3 axis)

Frame alignment correction of the accelerometer triad is represented by the 3x3 matrix multiplication operation:

$$\begin{bmatrix} Ax \\ Ay \\ Az \end{bmatrix} = \begin{bmatrix} R\_MATRIX\_A\_M11 & R\_MATRIX\_A\_M12 & R\_MATRIX\_A\_M13 \\ R\_MATRIX\_A\_M21 & R\_MATRIX\_A\_M22 & R\_MATRIX\_A\_M23 \\ R\_MATRIX\_A\_M31 & R\_MATRIX\_A\_M32 & R\_MATRIX\_A\_M33 \end{bmatrix} \begin{bmatrix} ax \\ ay \\ az \end{bmatrix}$$

A: Accelerometer output data after the rotation matrix operation.

The output is X, Y, and Z of ACCL registers (REG[0x1E ~ 0x29(W0)]).

M: Misalignment 3x3 matrix

a: Measurement data (3 axis)

Note):The initial value for M (misalignment matrix) is the identity matrix.

When M is unmodified, G = g, A = a.

Note):The frame alignment correction function is not supported when

SMPL\_CTRL[0x05(W1)] = 2000,400,80sps.

Note) when External trigger Type B is used, Frame Alignment Correction is not supported.

Refer to 8.1.10 Frame Alignment Correction (SPI) for an example of setting the rotation matrix coefficients.

## 5.17 RunTimeDIAG

The RunTimeDIAG function is a self-diagnosis function that is active during sampling. This function actively detects two types of error mechanisms during sampling mode:

- Communication fault with the Gyro sensor
- Sensor output abnormality with the Accelerometer

The detection is performed by "RunTimeDiag" block in the processing order as described in Figure 5.4 Functional Block Diagram. The notification to the host is made by register statuses and DIAG output signal.

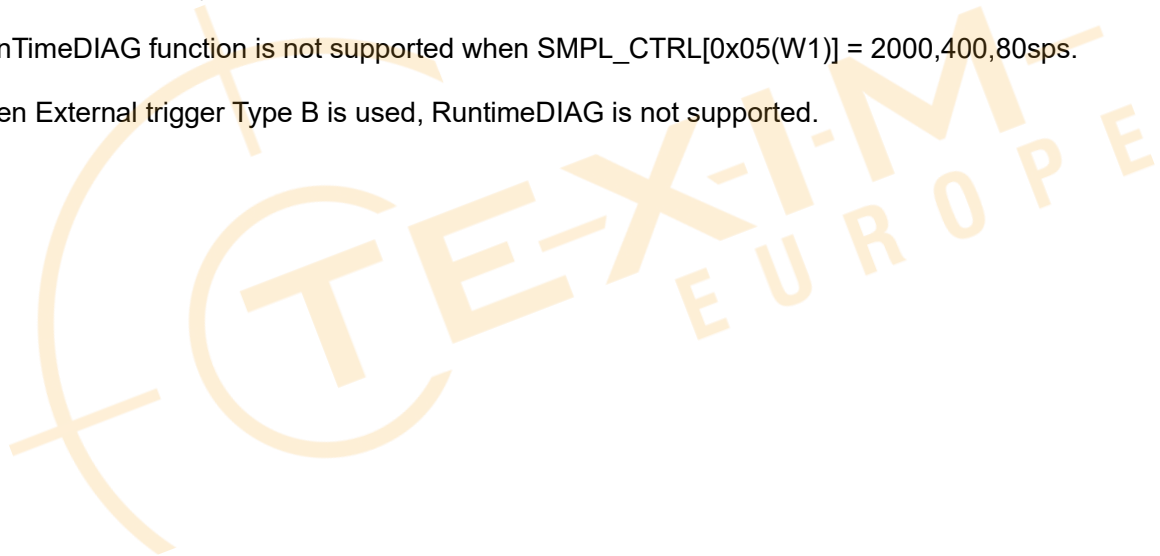
In case of registers, the host can confirm that a self-diagnosis error has occurred by reading the RTD bit of FLAG(ND/EA) in the burst read data or register [0x06(W0)] bit[1]. The source of self-diagnosis error can be confirmed by reading RT\_DIAG[0x2A(W0)] bit[13:8]. The bits in RT\_DIAG[0x2A(W0)] bit[13:8] is reset after reading the register.

Refer to 7.4 FLAG(ND/EA) Register (Window 0) and 7.11 RT\_DIAG Register (Window 0) for further information.

In case of DIAG output signal, the host can confirm the self-diagnosis error checking the state of the RTD pin (Refer to Table 2.6 Pin No18). The RTD pin is asserted HIGH when at least one error occurs in RT\_DIAG[0x2A(W0)] bit[13:8]. The RTD pin is asserted LOW after reading RT\_DIAG[0x2A(W0)] bits[13:8] which clears any bits to zero.

Note) RunTimeDIAG function is not supported when SMPL\_CTRL[0x05(W1)] = 2000,400,80sps.

Note) when External trigger Type B is used, RuntimeDIAG is not supported.



## 6. Digital Interface

This device has the following two external interfaces.

- (1) SPI interface
- (2) UART interface

The SPI interface and the UART interface have almost the same functions, except additionally the UART interface supports Auto Mode function. Because both interfaces are always active, the user needs only to connect the desired interface pins SPI or UART, without needing any hardware pin configuration or selection.

NOTE: Connecting both SPI and UART at the same time is not supported and may result in malfunction of the device.

The registers inside the device are accessed via the SPI or UART interfaces.

In this document, data sent to the device is called a "Command" and data sent back in response to the command is called a "Response". There are two types of commands: write command and read command. The write command has no response. The write command always writes to the internal register in 8-bit words. The response to the read command, i.e. the data from the internal register, is always read in 16-bit words.

When reading from the registers, there is a special mode called the burst mode in addition to the normal mode.

When the IMU output data rate is high (i.e. 1000sps), it is possible to exceed the bandwidth of the host interface and cause the data transmission to be incorrect. In this case, the user must balance the transmission data rate and the bandwidth capability of the host interface.

Adjust the following settings accordingly to optimize the host interface bandwidth:

- For the UART, adjust the baud rate in **BAUD\_RATE** (UART\_CTRL [0x08(W1)] bit 8).
- For the SPI, adjust the host side SPI clock frequency and SPI wait time.

Adjust the following settings accordingly to optimize the transmission data rate:

- The transmission data rate is affected by the data output rate setting in **DOUT\_RATE** (SMPL\_CTRL [0x04(W1)] bits [15:8]).
- The transmission data rate is also affected by the number of output bytes included in burst mode read transfer. The adjustment to the number of output bytes is in registers BURST\_CTRL1 [0x0C(W1)] and BURST\_CTRL2 [0x0E(W1)].

Several concrete examples for setting the transmission data rate and host interface bandwidth are shown below:

(1) For UART and 32-bit output:

Baudrate: 921600 Baud, Data output rate: 2000sps

- **BAUD\_RATE** = "10" of UART\_CTRL [0x08(W1)] bit[9:8]: 921600 baud
- **UART\_AUTO** = "1" of UART\_CTRL [0x08(W1)] bit [0]: UART Auto Mode
- **DOUT\_RATE** = 0x00 of SMPL\_CTRL [0x04(W1)] bit [15:8]: 2000Sps
- BURST\_CTRL1 [0x0C(W1)] = 0xF006: FLAG, TEMP, angle rate, acceleration, GPIO, and COUNT output
- BURST\_CTRL2 [0x0E(W1)] = 0x7000: TEMP, angle rate, and acceleration output are 32-bit.

Baudrate: 460800 Baud, Data output rate: 1000sps

- **BAUD\_RATE** = "00" of UART\_CTRL [0x08(W1)] bit[9:8]: 460800 baud
- **UART\_AUTO** = "1" of UART\_CTRL [0x08(W1)] bit [0]: UART Auto Mode
- **DOUT\_RATE** = 0x01 of SMPL\_CTRL [0x04(W1)] bit [15:8]: 1000Sps
- BURST\_CTRL1 [0x0C(W1)] = 0xF006: FLAG, TEMP, angle rate, acceleration, GPIO, and COUNT output
- BURST\_CTRL2 [0x0E(W1)] = 0x7000: TEMP, angle rate, and acceleration output are 32-bit.

(2) For SPI and 32-bit output:

- SPI Interface Transmission Setting: FSCLK=1MHz and tSTALL=24us for normal mode

- **DOUT\_RATE** = 0x01 of SMPL\_CTRL [0x04(W1)] bit [15:8]: 1000Sps
- BURST\_CTRL1 [0x0C(W1)] = 0xF006: FLAG, TEMP, angle rate, acceleration, GPIO, and COUNT output
- BURST\_CTRL2 [0x0E(W1)] = 0x7000: All TEMP, angle rate, and acceleration output are 32-bit.

(3) For UART and 16-bit output:

- **BAUD\_RATE** = "00" of UART\_CTRL [0x08(W1)] bit[9:8]: 460800 baud
- **UART\_AUTO** = "1" of UART\_CTRL [0x08(W1)] bit [0]: UART Auto Mode
- **DOUT\_RATE** = 0x01 of SMPL\_CTRL [0x04(W1)] bit [15:8]: 1000Sps
- BURST\_CTRL1 [0x0C(W1)] = 0xF006: FLAG, TEMP, angle rate, acceleration, GPIO, and COUNT output
- BURST\_CTRL2 [0x0E(W1)] = 0x0000: All TEMP, angle rate, and acceleration output are 16-bit.

(4) For SPI and 16-bit output:

- SPI Interface Transmission Setting: FSCLK=1MHz and tSTALL=24us for normal mode
- **DOUT\_RATE** = 0x01 of SMPL\_CTRL [0x04(W1)] bit [15:8]: 1000Sps
- BURST\_CTRL1 [0x0C(W1)] = 0xF006: FLAG, TEMP, angle rate, acceleration, GPIO, and COUNT output
- BURST\_CTRL2 [0x0E(W1)] = 0x0000: All TEMP, angle rate, and acceleration output are 16-bit.

## 6.1 SPI Interface

Table 6.1 shows the communication settings of SPI interface and Table 6.2 shows the SPI timing for normal mode.

Table 6.1 SPI Communication Settings

Parameter	Set value
Mode	Slave
Word length	16 bits
Phase	Rising edge
Polarity	Negative logic

Table 6.2 SPI Timing (Normal Mode)

Parameter	Minimum	Maximum	Unit
f <sub>SCLK</sub>	0.01	2.0	MHz
t <sub>STALL</sub>	20	-	μs
t <sub>WRITERATE</sub>	40	-	μs
t <sub>READRATE</sub>	40	-	μs

### 6.1.1 SPI Read Timing (Normal Mode)

The response data to a read command, i.e. the data from the internal register, is always returned in 16-bit words. The SPI interface supports sending the next command during the same bus cycle as receiving a response to the read command (full-duplex).

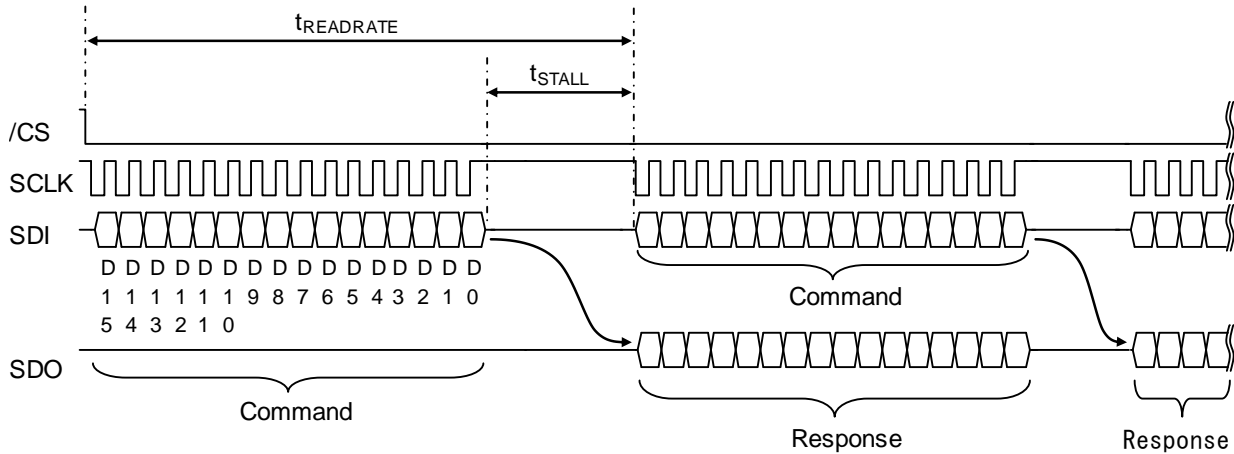


Figure 6.1 SPI Read Timing (Normal Mode)

Table 6.3 Command Format (Read)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	A[6:0]							XX							

A 6:0 ... Register address (even address)  
 XX ... Don't Care

Table 6.4 Response Format (Read)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
D[15:8]								D[7:0]							

D 15:8 ... Register read data (upper byte)  
 D 7:0 ... Register read data (lower byte)

### 6.1.2 SPI Write Timing (Normal Mode)

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

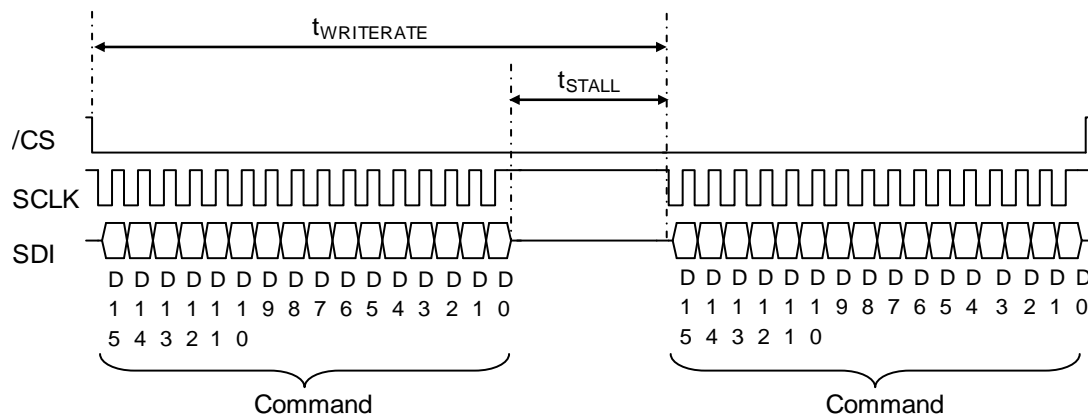


Figure 6.2 SPI Write Timing (Normal Mode)

Table 6.5 Command Format (Write)

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
1	A[6:0]							D[7:0]							

A 6:0 ... Register address (even or odd number)

D 7:0 ... Register write data

### 6.1.3 SPI 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 flag/EA flag, temperature sensor value, 3-axis gyroscope sensor value, 3-axis acceleration sensor value, GPIO, etc. are consecutively sent as a response. The response format for the burst read output data is configured by register setting in BURST\_CTRL1 [0x0C(W1)] and BURST\_CTRL2 [0x0E(W1)]. Please refer to 6.3 Data Packet Format for the response format.

Table 6.6 SPI Timing (Burst Mode)

Parameter	Minimum	Maximum	Unit
f <sub>SCLK</sub>	0.01	1.0	MHz
t <sub>STALL1</sub>	45	-	μs
t <sub>STALL2</sub>	4	-	μs
t <sub>READRATE2</sub>	32	-	μs

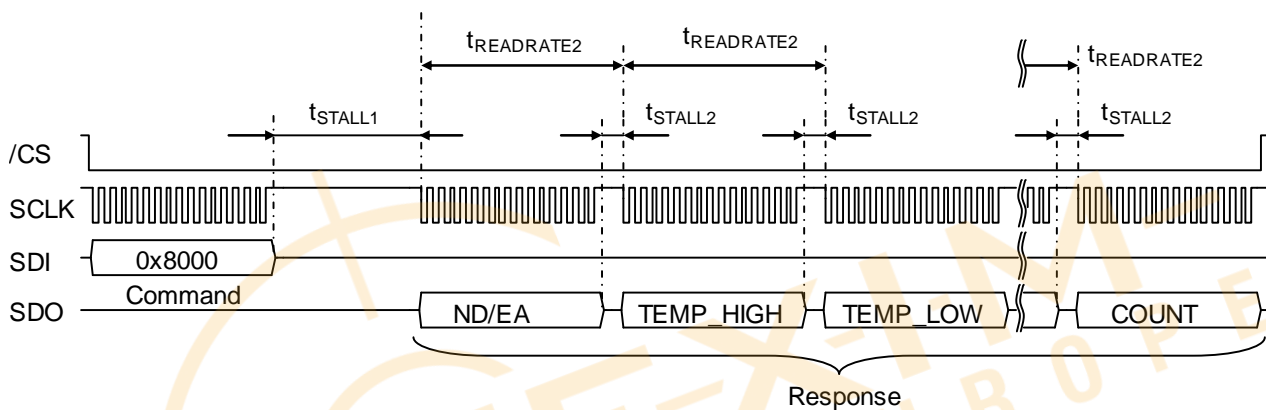


Figure 6.3 SPI Timing (Burst Mode)

NOTE: SPI Read Burst Mode can support t<sub>STALL2</sub> = 0μs under the following conditions.

- BURST\_CTRL1 [0x0C(W1)]: Set value 0xF003: FLAG, Temperature, Angular Rate, Acceleration, Count, Checksum  
BURST\_CTRL2 [0x0E(W1)]: Set value 0x3000: Angular Rate & Acceleration output is 32-bit
- f<sub>SCLK</sub>: Maximum 500kHz.
- t<sub>STALL1</sub>: Minimum 45us.
- t<sub>STALL2</sub>: 0 us
- t<sub>READRATE2</sub>: Minimum 32us.
- External Counter Reset or External Trigger Input is not supported
  - MSC\_CTRL[0x02(W1)] bit[7:6] = 00

## 6.2 UART Interface

Table 6.7 shows the supported UART communication settings and Figure 6.4 shows the UART bit format. Please refer to **BAUD\_RATE** (UART\_CTRL [0x08(W1)] bit 8) for changing the baud rate setting.

Table 6.7 UART Communication Settings

Parameter	Set value
Transfer rate	230.4kbps/460.8kbps/921.6kbps
Start	1 bit
Data	8 bits
Stop	1 bit
Parity	None
Delimiter	CR(0x0D)

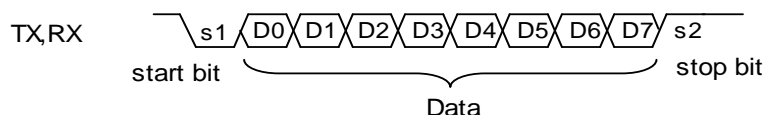


Figure 6.4 UART Bit Format

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 6.8 and Table 6.9 shows the timing of UART.

Table 6.8 UART Timing

Parameter	Manual mode				Auto mode		Unit
	Normal mode		Burst mode		Minimum	Maximum	
	Minimum	Maximum	Minimum	Maximum			
tSTALL(230.4kbps)	-	25	-	70	-	- <sup>*2</sup>	μs
tSTALL(460.8kbps)	-	25	-	70	-	- <sup>*2</sup>	μs
tSTALL(921.6kbps)	-	25	-	70	-	- <sup>*2</sup>	μs
tWRITERATE(230.4kbps)	350	-	-	-	350	-	μs
tWRITERATE(460.8kbps)	200	-	-	-	200	-	μs
tWRITERATE(921.6kbps)	150	-	-	-	150	-	μs
tREADRATE(230.4kbps)	350	-	<sup>*1</sup>	-	- <sup>*2</sup>	-	μs
tREADRATE(460.8kbps)	200	-	<sup>*1</sup>	-	- <sup>*2</sup>	-	μs
tREADRATE(921.6kbps)	150	-	<sup>*1</sup>	-	- <sup>*2</sup>	-	μs

\*1) Please refer to Table 6.9.

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

Table 6.9 UART Timing (tREADRATE requirements for Burst Mode)

Parameter	Burst Mode (minimum)	Unit
tREADRATE(230.4kbps)	$300 + (43.4 * B)$	μs
tREADRATE(460.8kbps)	$200 + (21.7 * B)$	μs
tREADRATE(921.6kbps)	$150 + (10.9 * B)$	μs

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

Example tREADRATE Calculation:

BURST\_CTRL1 [0x0C(W1)]: Set value 0xF006  
 BURST\_CTRL2[ 0x0E(W1)]: Set value 0x7000  
 B=34 byte for the above stated register setting  
 $tREADRATE(460.8kbps) = 200 + (21.7 * 34) = 937.8(\mu s)$

### 6.2.1 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.

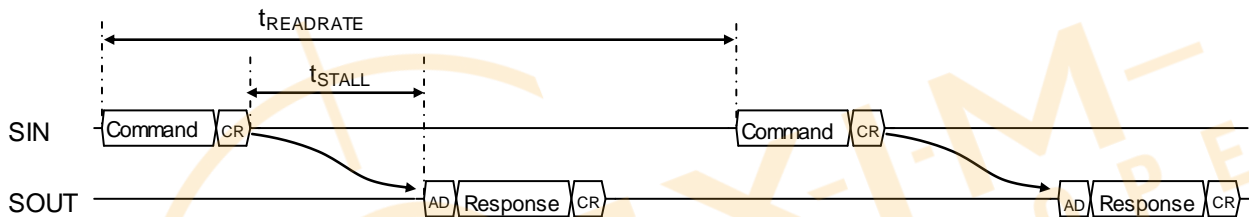


Figure 6.5 UART Read Timing (Normal Mode)

Table 6.10 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 6.11 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

### 6.2.2 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 flag/EA flag, temperature sensor value, 3-axis gyroscope sensor value, 3-axis acceleration sensor value, GPIO, etc. are consecutively sent as a response. The response format for the burst read output data is configured by register setting in BURST\_CTRL1 [0x0C(W1)] and BURST\_CTRL2 [0x0E(W1)]. Please refer to 6.3 Data Packet Format for the response format.

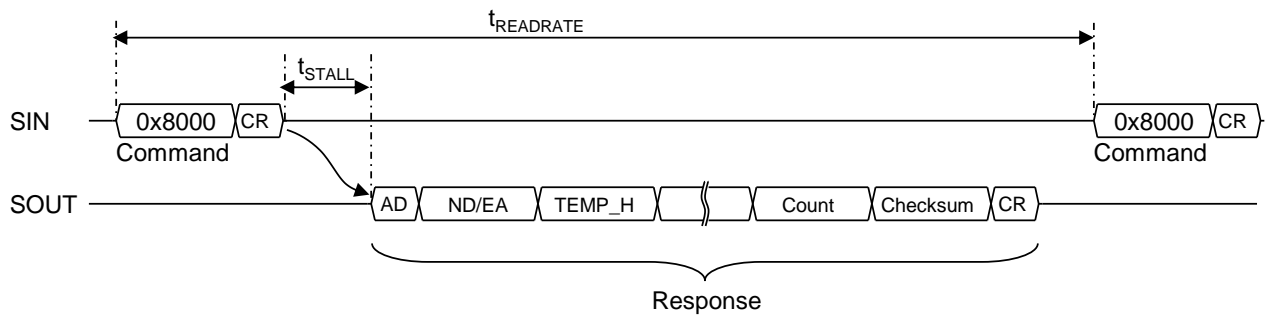


Figure 6.6 UART Read Timing (Burst Mode)

Table 6.12 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

### 6.2.3 UART Write Timing

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

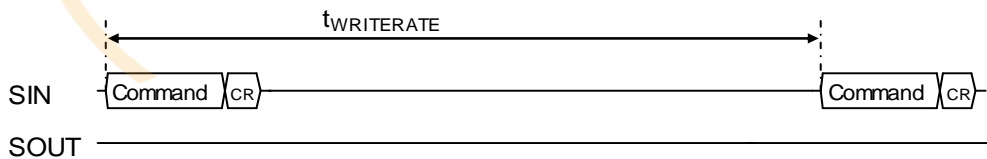


Figure 6.7 UART Write Timing

Table 6.13 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

### 6.2.4 UART Auto Mode Operation

When UART Auto Mode 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 6.3 UART Data Packet Format. The response format for the burst read output data is configured by register setting in BURST\_CTRL1 [0x0C(W1)] and BURST\_CTRL2 [0x0E(W1)].

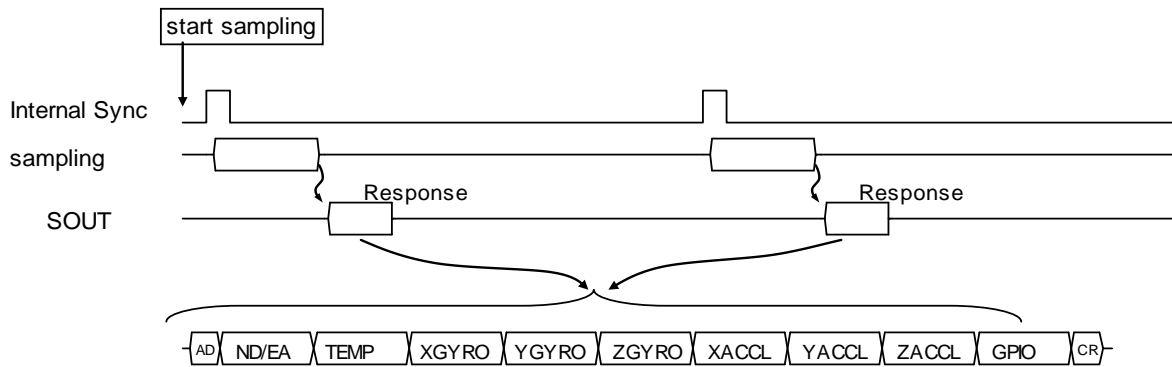


Figure 6.8 UART Auto Mode Operation



### 6.3 Data Packet Format

The following table shows example of the burst data packet format sent to the host with UART and SPI.

Table 6.14 UART Data Packet Format (UART Burst/Auto Mode) Example: 16-bit Output  
BURST\_CTRL1[0x0C(W1)]=0xF007 / BURST\_CTRL2[0x0E(W1)]=0x0000

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1	ADDRESS	0x80							
2	ND	ND (Temp)	ND (XGyro)	ND (YGyro)	ND (ZGyro)	ND (XACCL)	ND (YACCL)	ND (ZACCL)	RO
3	EA	ND (XDLTA)	ND (YDLTA)	ND (ZDLTA)	ND (XDLTV)	ND (YDLTV)	ND (ZDLTV)	RTD	EA
4	TEMP_HIGH_H	TEMP_HIGH [15:8]							
5	TEMP_HIGH_L	TEMP_HIGH [7:0]							
6	XGYRO_HIGH_H	XGYRO_HIGH [15:8]							
7	XGYRO_HIGH_L	XGYRO_HIGH [7:0]							
8	YGYRO_HIGH_H	YGYRO_HIGH [15:8]							
9	YGYRO_HIGH_L	YGYRO_HIGH [7:0]							
10	ZGYRO_HIGH_H	ZGYRO_HIGH [15:8]							
11	ZGYRO_HIGH_L	ZGYRO_HIGH [7:0]							
12	XACCL_HIGH_H	XACCL_HIGH [15:8]							
13	XACCL_HIGH_L	XACCL_HIGH [7:0]							
14	YACCL_HIGH_H	YACCL_HIGH [15:8]							
15	YACCL_HIGH_L	YACCL_HIGH [7:0]							
16	ZACCL_HIGH_H	ZACCL_HIGH [15:8]							
17	ZACCL_HIGH_L	ZACCL_HIGH [7:0]							
18	GPIO_H	-	-	-	-	-	-	GPIO_DATA2	GPIO_DATA1
19	GPIO_L	-	-	-	-	-	-	GPIO_DIR2	GPIO_DIR1
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							

Table 6.15 UART Data Packet Format (UART Burst/Auto Mode) Example: 32-bit Output

BURST\_CTRL1[0x0C(W1)]=0xF007 / BURST\_CTRL2[0x0E(W1)]=0x7000

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1	ADDRESS	0x80							
2	ND	ND (Temp)	ND (XGyro)	ND (YGyro)	ND (ZGyro)	ND (XACCL)	ND (YACCL)	ND (ZACCL)	RO
3	EA	ND (XDLTA)	ND (YDLTA)	ND (ZDLTA)	ND (XDLTV)	ND (YDLTV)	ND (ZDLTV)	RTD	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	XGYRO_HIGH_H	XGYRO_HIGH [15:8]							
9	XGYRO_HIGH_L	XGYRO_HIGH [7:0]							
10	XGYRO_LOW_H	XGYRO_LOW [15:8]							
11	XGYRO_LOW_L	XGYRO_LOW [7:0]							
12	YGYRO_HIGH_H	YGYRO_HIGH [15:8]							
13	YGYRO_HIGH_L	YGYRO_HIGH [7:0]							
14	YGYRO_LOW_H	YGYRO_LOW [15:8]							
15	YGYRO_LOW_L	YGYRO_LOW [7:0]							
16	ZGYRO_HIGH_H	ZGYRO_HIGH [15:8]							
17	ZGYRO_HIGH_L	ZGYRO_HIGH [7:0]							
18	ZGYRO_LOW_H	ZGYRO_LOW [15:8]							
19	ZGYRO_LOW_L	ZGYRO_LOW [7:0]							
20	XACCL_HIGH_H	XACCL_HIGH [15:8]							
21	XACCL_HIGH_L	XACCL_HIGH [7:0]							
22	XACCL_LOW_H	XACCL_LOW [15:8]							
23	XACCL_LOW_L	XACCL_LOW [7:0]							
24	YACCL_HIGH_H	YACCL_HIGH [15:8]							
25	YACCL_HIGH_L	YACCL_HIGH [7:0]							
26	YACCL_LOW_H	YACCL_LOW [15:8]							
27	YACCL_LOW_L	YACCL_LOW [7:0]							

28	ZACCL_HIGH_H	ZACCL_HIGH [15:8]							
29	ZACCL_HIGH_L	ZACCL_HIGH [7:0]							
30	ZACCL_LOW_H	ZACCL_LOW [15:8]							
31	ZACCL_LOW_L	ZACCL_LOW [7:0]							
32	GPIO_H	-	-	-	-	-	-	GPIO_DATA2	GPIO_DATA1
33	GPIO_L	-	-	-	-	-	-	GPIO_DIR2	GPIO_DIR1
34	COUNT_H	COUNT [15:8]							
35	COUNT_L	COUNT [7:0]							
36	CHECKSUM_H	CHECKSUM [15:8]							
37	CHECKSUM_L	CHECKSUM [7:0]							
38	CR	0x0D							

Table 6.16 DATA PACKET FORMAT (SPI BURST MODE) Example: 16-bit Output

BURST\_CTRL1[0x0C(W1)]=0xF007 / BURST\_CTRL2[0x0E(W1)]=0x0000

Word No.	Bit15	...	Bit0
1		FLAG(ND/EA)	
2		TEMP_HIGH	
3		XGYRO_HIGH	
4		YGYRO_HIGH	
5		ZGYRO_HIGH	
6		XACCL_HIGH	
7		YACCL_HIGH	
8		ZACCL_HIGH	
9		GPIO	
10		COUNT	
11		CHECKSUM	

Table 6.17 DATA PACKET FORMAT (SPI BURST MODE) Example: 32-bit Output  
 BURST\_CTRL1[0x0C(W1)]=0xF007 / BURST\_CTRL2[0x0E(W1)]=0x7000

Word No.	Bit15	...	Bit0
1		FLAG(ND/EA)	
2		TEMP_HIGH	
3		TEMP_LOW	
4		XGYRO_HIGH	
5		XGYRO_LOW	
6		YGYRO_HIGH	
7		YGYRO_LOW	
8		ZGYRO_HIGH	
9		ZGYRO_LOW	
10		XACCL_HIGH	
11		XACCL_LOW	
12		YACCL_HIGH	
13		YACCL_LOW	
14		ZACCL_HIGH	
15		ZACCL_LOW	
16		GPIO	
17		COUNT	
18		CHECKSUM	

Table 6.18 DATA PACKET FORMAT (UART BURST/AUTO MODE) Example: 32-bit Output

BURST\_CTRL1[0x0C(W1)]=0xFC07 / BURST\_CTRL2[0x0E(W1)]=0x7C00

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
1	ADDRESS	0x80							
2	ND	ND (Temp)	ND (XGyro)	ND (YGyro)	ND (ZGyro)	ND (XACCL)	ND (YACCL)	ND (ZACCL)	RO
3	EA	ND (XDLTA)	ND (YDLTA)	ND (ZDLTA)	ND (XDLTV)	ND (YDLTV)	ND (ZDLTV)	RTD	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	XGYRO_HIGH_H	XGYRO_HIGH [15:8]							
9	XGYRO_HIGH_L	XGYRO_HIGH [7:0]							
10	XGYRO_LOW_H	XGYRO_LOW [15:8]							
11	XGYRO_LOW_L	XGYRO_LOW [7:0]							
12	YGYRO_HIGH_H	YGYRO_HIGH [15:8]							
13	YGYRO_HIGH_L	YGYRO_HIGH [7:0]							
14	YGYRO_LOW_H	YGYRO_LOW [15:8]							
15	YGYRO_LOW_L	YGYRO_LOW [7:0]							
16	ZGYRO_HIGH_H	ZGYRO_HIGH [15:8]							
17	ZGYRO_HIGH_L	ZGYRO_HIGH [7:0]							
18	ZGYRO_LOW_H	ZGYRO_LOW [15:8]							
19	ZGYRO_LOW_L	ZGYRO_LOW [7:0]							
20	XACCL_HIGH_H	XACCL_HIGH [15:8]							
21	XACCL_HIGH_L	XACCL_HIGH [7:0]							
22	XACCL_LOW_H	XACCL_LOW [15:8]							
23	XACCL_LOW_L	XACCL_LOW [7:0]							
24	YACCL_HIGH_H	YACCL_HIGH [15:8]							
25	YACCL_HIGH_L	YACCL_HIGH [7:0]							
26	YACCL_LOW_H	YACCL_LOW [15:8]							
27	YACCL_LOW_L	YACCL_LOW [7:0]							

28	ZACCL_HIGH_ H	ZACCL_HIGH [15:8]
29	ZACCL_HIGH_ L	ZACCL_HIGH [7:0]
30	ZACCL_LOW_ H	ZACCL_LOW [15:8]
31	ZACCL_LOW_ L	ZACCL_LOW [7:0]
32	XDLTA_HIGH_ H	XDLTA_HIGH [15:8]
33	XDLTA_HIGH_ L	XDLTA_HIGH [7:0]
34	XDLTA_LOW_ H	XDLTA_LOW [15:8]
35	XDLTA_LOW_L	XDLTA_LOW [7:0]
36	YDLTA_HIGH_ H	YDLTA_HIGH [15:8]
37	YDLTA_HIGH_ L	YDLTA_HIGH [7:0]
38	YDLTA_LOW_ H	YDLTA_LOW [15:8]
39	YDLTA_LOW_L	YDLTA_LOW [7:0]
40	ZDLTA_HIGH_ H	ZDLTA_HIGH [15:8]
41	ZDLTA_HIGH_ L	ZDLTA_HIGH [7:0]
42	ZDLTA_LOW_ H	ZDLTA_LOW [15:8]
43	ZDLTA_LOW_L	ZDLTA_LOW [7:0]
44	XDLTV_HIGH_ H	XDLTV_HIGH [15:8]
45	XDLTV_HIGH_ L	XDLTV_HIGH [7:0]
46	XDLTV_LOW_ H	XDLTV_LOW [15:8]
47	XDLTV_LOW_L	XDLTV_LOW [7:0]
48	YDLTV_HIGH_ H	YDLTV_HIGH [15:8]
49	YDLTV_HIGH_ L	YDLTV_HIGH [7:0]
50	YDLTV_LOW_ H	YDLTV_LOW [15:8]
51	YDLTV_LOW_L	YDLTV_LOW [7:0]
52	ZDLTV_HIGH_ H	ZDLTV_HIGH [15:8]
53	ZDLTV_HIGH_ L	ZDLTV_HIGH [7:0]
54	ZDLTV_LOW_ H	ZDLTV_LOW [15:8]
55	ZDLTV_LOW_L	ZDLTV_LOW [7:0]

56	GPIO_H	-	-	-	-	-	-	GPIO_DATA2	GPIO_DATA1
57	GPIO_L	-	-	-	-	-	-	GPIO_DIR2	GPIO_DIR1
58	COUNT_H	COUNT [15:8]							
59	COUNT_L	COUNT [7:0]							
60	CHECKSUM_H	CHECKSUM [15:8]							
61	CHECKSUM_L	CHECKSUM [7:0]							
62	CR	0x0D							



## 7. User Registers

A host device (for example, a microcontroller) can control the IMU 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 IMU registers are only accessed after the Power-On Start-Up 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 IMU 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**
- GPIO [0x08(W0)] bit [9:8] in **GPIO\_DATA**
- GLOB\_CMD [0x0A(W1)] bit 7 in **SOFT\_RST**
- WIN\_CTRL [0x7E(W0/W1)] bit [7:0] in **WINDOW\_ID**

While in the UART Auto Mode and Sampling Mode is active, register read access is not supported. Otherwise, the sampling data transmitted in the UART Auto Mode 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 7.18 describes the registers in detail.

The "-" sign in the register assignment table in Section 7.1 through Section 7.18 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

Name	Window ID	Address	R/W	Flash Backup	Default	Function
BURST	0	0x00	W		-	Burst mode
MODE_CTRL	0	0x03,0x02	R/W		0x0400	Operation mode control
DIAG_STAT	0	0x04	R		0x0000	Diagnostic result
FLAG	0	0x06	R		0x0000	ND flag/EA flag
GPIO	0	0x09,0x08	R/W		0x0200	GPIO
COUNT	0	0x0A	R		0x0000	Sampling count value
RANGE_OVER	0	0x0C	R		0x0000	Range Over
TEMP_HIGH	0	0x0E	R		0xFFFF	Temperature sensor value High
TEMP_LOW	0	0x10	R		0xFFFF	Temperature sensor value Low
XGYRO_HIGH	0	0x12	R		0xFFFF	X gyroscope sensor value High
XGYRO_LOW	0	0x14	R		0xFFFF	X gyroscope sensor value Low
YGYRO_HIGH	0	0x16	R		0xFFFF	Y gyroscope sensor value High
YGYRO_LOW	0	0x18	R		0xFFFF	Y gyroscope sensor value Low
ZGYRO_HIGH	0	0x1A	R		0xFFFF	Z gyroscope sensor value High
ZGYRO_LOW	0	0x1C	R		0xFFFF	Z gyroscope sensor value Low
XACCL_HIGH	0	0x1E	R		0xFFFF	X acceleration sensor value High
XACCL_LOW	0	0x20	R		0xFFFF	X acceleration sensor value Low
YACCL_HIGH	0	0x22	R		0xFFFF	Y acceleration sensor value High
YACCL_LOW	0	0x24	R		0xFFFF	Y acceleration sensor value Low
ZACCL_HIGH	0	0x26	R		0xFFFF	Z acceleration sensor value High
ZACCL_LOW	0	0x28	R		0xFFFF	Z acceleration sensor value Low
RT_DIAG	0	0x2B	R		0x0000	Run Time Diag
ID	0	0x4C	R		0x5345	ID read function
XDLTA_HIGH	0	0x64	R		0x0000	X delta angle value High
XDLTA_LOW	0	0x66	R		0x0000	X delta angle value Low
YDLTA_HIGH	0	0x68	R		0x0000	Y delta angle value High
YDLTA_LOW	0	0x6A	R		0x0000	Y delta angle value Low
ZDLTA_HIGH	0	0x6C	R		0x0000	Z delta angle value High
ZDLTA_LOW	0	0x6E	R		0x0000	Z delta angle value Low
XDLTV_HIGH	0	0x70	R		0x0000	X delta velocity value High
XDLTV_LOW	0	0x72	R		0x0000	X delta velocity value Low
YDLTV_HIGH	0	0x74	R		0x0000	Y delta velocity value High
YDLTV_LOW	0	0x76	R		0x0000	Y delta velocity value Low
ZDLTV_HIGH	0	0x78	R		0x0000	Z delta velocity value High
ZDLTV_LOW	0	0x7A	R		0x0000	Z delta velocity value Low
SIG_CTRL	1	0x01,0x00	R/W	○	0xFE00	DataReady signal & polarity

						control
MSC_CTRL	1	0x03,0x02	R/W	○	0x0006	Other control
SMPL_CTRL	1	0x05,0x04	R/W	○	0x0107	Sampling control
FILTER_CTRL	1	0x07,0x06	R/W	○	0x0001	Filter control
UART_CTRL	1	0x09,0x08	R/W	○	0x0000	UART control
GLOB_CMD	1	0x0B,0x0A	R/W	○	0x0000	System control
BURST_CTRL1	1	0x0D,0x0C	R/W	○	0xF006	Burst control 1
BURST_CTRL2	1	0x0F,0x0E	R/W	○	0x0000	Burst control 2
POL_CTRL	1	0x11,0x10	R/W	○	0x0000	Polarity control
DLT_CTRL	1	0x13,0x12	R/W	○	0x00CC	Delta control
ATTI_CTRL	1	0x15,0x14	R/W		0x0000	Attitude control
GLOB_CMD2	1	0x17,0x16	R/W		0x0001	System control2
R_MATRIX_G_M11 *1	1	0x39,0x38	R/W	○	0x4000	Gyro R_Matrix coefficient
R_MATRIX_G_M12 *1	1	0x3B,0x3A	R/W	○	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M13 *1	1	0x3D,0x3C	R/W	○	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M21 *1	1	0x3F,0x3E	R/W	○	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M22 *1	1	0x41,0x40	R/W	○	0x4000	Gyro R_Matrix coefficient
R_MATRIX_G_M23 *1	1	0x43,0x42	R/W	○	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M31 *1	1	0x45,0x44	R/W	○	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M32 *1	1	0x47,0x46	R/W	○	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M33 *1	1	0x49,0x48	R/W	○	0x4000	Gyro R_Matrix coefficient
R_MATRIX_A_M11 *1	1	0x4B,0x4A	R/W	○	0x4000	Accel R_Matrix coefficient
R_MATRIX_A_M12 *1	1	0x4D,0x4C	R/W	○	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M13 *1	1	0x4F,0x4E	R/W	○	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M21 *1	1	0x51,0x50	R/W	○	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M22 *1	1	0x53,0x52	R/W	○	0x4000	Accel R_Matrix coefficient
R_MATRIX_A_M23 *1	1	0x55,0x54	R/W	○	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M31 *1	1	0x57,0x56	R/W	○	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M32 *1	1	0x59,0x58	R/W	○	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M33 *1	1	0x5B,0x5A	R/W	○	0x4000	Accel R_Matrix coefficient
PROD_ID1	1	0x6A	R		0xFFFF	Product ID
PROD_ID2	1	0x6C	R		0xFFFF	Product ID
PROD_ID3	1	0x6E	R		0xFFFF	Product ID
PROD_ID4	1	0x70	R		0xFFFF	Product ID
VERSION	1	0x72	R		0xFFFF	Version
SERIAL_NUM1	1	0x74	R		0xFFFF	Serial Number
SERIAL_NUM2	1	0x76	R		0xFFFF	Serial Number
SERIAL_NUM3	1	0x78	R		0xFFFF	Serial Number
SERIAL_NUM4	1	0x7A	R		0xFFFF	Serial Number
WIN_CTRL	0,1	0x7F,0x7E	R/W		0x0000	Register window control

\*1 The R\_MATRIX\_\*\_coefficient values are stored in non-volatile memory using GLOB\_CMD2[0x17(W1)] bit 8.

## 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\_CTRL1 [0x0C(W1)] and BURST\_CTRL2 [0x0E(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) Only MODE\_STAT is read-only.

**bit[10] MODE\_STAT**

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

1: Configuration mode

0: Sampling mode

**bit[9:8] MODE\_CMD**

Executes commands related to the operation mode.

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: (Not used)

00: (Not used)

### 7.3 DIAG\_STAT Register (Window 0)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x05	-	ST_ERR (XGyro)	ST_ERR (YGyro)	ST_ERR (ZGyro)	ST_ERR (ACCL)	SET_ERR	DLTA_OVF	DLTV_OVF	R

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x04	-	HARD_ERR		SPI_OVF	UART_OVF	FLASH_ERR	ST_ERR_ALL	FLASH_BUFFER	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[14:11] ST\_ERR (SelfTest ERROR)

Shows the result of **SELF\_TEST** (internal self test) of MSC\_CTRL [0x02(W1)] bit 10.

- 1 :Error occurred
- 0 :No error

#### bit[10] SET\_ERR (SET ERROR)

Shows a SET ERROR condition has occurred.

SET ERROR condition occurs when Delta Angle / Delta Velocity is disabled and an invalid setting is detected with any of the following:

- Invalid combination of Output rate setting (SMPL\_CTRL[0x05(W1)] bit [11:8]) and filter setting (FILTER\_CTRL[0x06(W1)] bit [4:0])
- Delta Angle/Velocity output is enabled (ATTI\_ON[0x15(W1)] bit [10:9] = 01), and external trigger input is enabled (MSC\_CTRL[0x02(W1)] bit [7:6]=10).

- 1 :Error occurred
- 0 :No error

#### bit[9] DLTA\_OVF (DeLTa Angle Over Flow)

Shows an overflow error condition of the Delta Angle.

- 1 :Error occurred
- 0 :No error

#### bit[8] DLTV\_OVF (DeLTa V Over Flow)

Shows an overflow error condition of the Delta Velocity.

- 1 :Error occurred
- 0 :No error

#### bit[6:5] HARD\_ERR

Shows the result of the hardware check at startup.

- Other than 00 :Error occurred
- 00 :No error

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

#### bit[4] SPI\_OVF (SPI Over Flow)

Shows an error occurred if the device received too many commands from the SPI interface in short period of time.

- 1 :Error occurred
- 0 :No error

When this error occurs, review the SPI command transmission interval and the SPI clock setting.

**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 baud rate, data output rate, UART Burst/Auto Mode in combination. Refer to BAUD\_RATE of UART\_CTRL[0x08(W1)] bit [9:8], DOUT\_RATE of SMPL\_CTRL[0x04(W1)] bit [15:8]. If using burst mode with UART automatic mode, also review BURST\_CTRL1[0x0C(W1)] and BURST\_CTRL2[0x0E(W1)] settings.

**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] ST\_ERR\_ALL (SelfTest Error All)**

Shows the logical sum of bit [14:11] 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 (XGyro)	ND (YGyro)	ND (ZGyro)	ND (XACCL)	ND (YACCL)	ND (ZACCL)	RO	R

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x06	ND (XDLTA)	ND (YDLTA)	ND (ZDLTA)	ND (XDLTV)	ND (YDLTV)	ND (ZDLTV)	RTD	EA	R

**bit[15:9] ND(New Data) flag (Temperature, Gyroscope, Acceleration)**

When a new measuring data is set in each register of temperature (TEMP\_HIGH), gyroscope (XGYRO\_HIGH, YGYRO\_HIGH, ZGYRO\_HIGH), and acceleration (XACCL\_HIGH, YACCL\_HIGH, ZACCL\_HIGH), the corresponding ND flag is set to "1". When the measurement output is read from the corresponding register, the flag is reset to "0".

**bit[8] RO(Range Over) flag**

When at least one over range condition is detected in RANGE\_OVER[0x0C(W0)], this flag is set to "1".

**bit[7:2] ND(New Data) flag (Delta Angle, Delta Velocity)**

When a new measuring data is set in each register of delta angle (XDLTA\_HIGH, YDLTA\_HIGH, ZDLTA\_HIGH), and delta velocity (XDLTV\_HIGH, YDLTV\_HIGH, ZDLTV\_HIGH), the corresponding ND flag is set to "1". When the measurement output is read from the corresponding register, the flag is reset to "0".

**bit[1] RTD(Run Time Diag) flag**

When at least one abnormality is detected in the run time self-diagnosis result (RT\_DIAG [0x2B(W0)]), this flag is set to "1".

**bit[0] EA(All Error) flag**

When at least one failure is found in the diagnostic result (DIAG\_STAT [0x04(W0)]), the flag is set to "1"(failure occurred).

## 7.5 GPIO Register (Window 0)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x09	-	-	-	-	-	-	GPIO_DATA2	GPIO_DATA1	R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x08	-	-	-	-	-	-	GPIO_DIR2	GPIO_DIR1	R/W

### bit[9:8] GPIO\_DATA

If the corresponding **GPIO\_DIR** bit is set to “output”, the value set in the **GPIO\_DATA** is output to the GPIO port.

If the corresponding **GPIO\_DIR** bit is set to “input”, the input level of the GPIO port is returned by reading the **GPIO\_DATA**.

1 :High Level

0 :Low Level

### bit[1:0] GPIO\_DIR

Each bit controls the bitwise direction of the GPIO port.

1 :Output

0 :Input

NOTE) GPIO1 is shared with the Data Ready signal function on the same terminal. The terminal functions as GPIO1 when **DRDY\_ON** is 0 (disabled). The selection between GPIO1 and Data Ready signal is controlled with **DRDY\_ON** of **MSC\_CTRL** [0x02(W1)] bit 2.

NOTE) GPIO2 is shared with the EXT signal input function (External Trigger Input and External Counter Reset Input) on the same terminal. The terminal functions as GPIO2 when **EXT\_SEL** is 00 (GPIO2). The selection between GPIO2 and the EXT signal input is controlled with **EXT\_SEL** of **MSC\_CTRL** [0x02(W1)] bit [7:6].

## 7.6 COUNT Register (Window 0)

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

### bit[15:0] COUNT

The value returned by this register depends on whether the External Counter Reset Input function is enabled or not. The External Counter Reset Input is enabled when **EXT\_SEL** of **MSC\_CTRL** [0x02(W1)] bit [7:6] = 01.

When the External Counter Reset Input function is disabled, this register returns the sampling count value of the internal A/D converter which depends on **SMPL\_CTRL**[0x05(W1)] as follows:

- **SMPL\_CTRL**[0x05(W1)] = 2000,400 and 80sps, the interval is 500μs/count.
- **SMPL\_CTRL** 0x05(W1) = 1000,500,250,125, 62.5, 15.625, 200,100, 50, 40, 25, and 20sps, the interval is 1000us/count.

Example: If the data output rate equals 500Sps, the counter value sequence is 0,2,4,6, ... , 0xFFFFE, 0, 2, ....

When the External Counter Reset Input function is enabled, this register returns the timer counter value used by the External Counter Reset Input function.

## 7.7 RANGE OVER Register (Window 0)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x0D	-		RO (XGyro)	RO (YGyro)	RO (ZGyro)	RO (XACCL)	RO (YACCL)	RO (ZACCL)	R

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

### bit[13:8] RO(Range Over) Flag (Gyroscope/Acceleration)

The specified gyroscope or acceleration sensor axis RO flag is set to "1" when the output value exceeds the sensing range. The flags are reset to "0" by reading this register.

## 7.8 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.

The output data format is 32-bit two's complement format. For 16-bit usage, treat the data as 16-bits two's complement using the upper 16-bits (**TEMP\_HIGH**).

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.

$$\text{For 32-bit usage: } T [^{\circ}\text{C}] = (\text{SF}/65536) * (A - 172621824) + 25$$

$$\text{For 16-bit usage: } T [^{\circ}\text{C}] = \text{SF} * (A - 2634) + 25$$

SF : Scale Factor (16bit)

A: Temperature sensor output data (decimal)

NOTE: 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.

## 7.9 GYRO Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x12		XGYRO_HIGH		R
0x14		XGYRO_LOW		R
0x16		YGYRO_HIGH		R
0x18		YGYRO_LOW		R
0x1A		ZGYRO_HIGH		R
0x1C		ZGYRO_LOW		R

### bit[15:0] Gyroscope output data

Returns the 3-axis gyroscope data for X, Y, and Z as referenced in Figure 3.1 Outline Dimensions (millimeters).

The output data format is 32-bits two's complement. For 16-bit usage, treat the data as 16-bits two's complement using the upper 16-bits.

Please refer to Table 2.3 Sensor Specification for the Scale Factor value.

For 32-bit usage:,  $G \text{ [deg/s]} = (1/SF/65536) * B$

For 16-bit usage:  $G \text{ [deg/s]} = 1/SF * B$

SF : Scale Factor (16bit)  
B: Gyroscope output data (decimal)

## 7.10 ACCL Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x1E		XACCL_HIGH		R
0x20		XACCL_LOW		R
0x22		YACCL_HIGH		R
0x24		YACCL_LOW		R
0x26		ZACCL_HIGH		R
0x28		ZACCL_LOW		R

### bit[15:0] Acceleration sensor output data

Returns the 3-axis acceleration data for X, Y, and Z as referenced in Figure 3.1 Outline Dimensions (millimeters).

The output data format is 32-bits two's complement. For 16-bit usage, treat the data as 16-bits two's complement using the upper 16-bits.

Please refer to Table 2.3 Sensor Specification for the Scale Factor value.

For 32-bit usage:,  $A \text{ [mG]} = (1/SF/65536) * C$

For 16-bit usage:  $A \text{ [mG]} = 1/SF * C$

SF : Scale Factor (16bit)  
C: Acceleration sensor output data (decimal)

### 7.11 RT\_DIAG Register (Window 0)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x2B	-		RTD (XGyro)	RTD (YGyro)	RTD (ZGyro)	RTD (XACCL)	RTD (YACCL)	RTD (ZACCL)	R

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x2A	-								R

#### bit[13:8] RTD(Run Time Diag) Flag (Gyroscope/Acceleration)

The specified gyroscope or acceleration sensor RTD flag is set to "1" and the DIAG output pin is asserted HIGH when the self-diagnosis detects an abnormality. The flags are reset to 0 and the DIAG output pin is asserted LOW after reading this register.

### 7.12 ID Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x4C	ID			R

#### bit[15:0] ID data

This register will return the value "0x5345" when read.

### 7.13 DELTA\_ANGLE Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x64	XDLTA_HIGH			R
0x66	XDLTA_LOW			R
0x68	YDLTA_HIGH			R
0x6A	YDLTA_LOW			R
0x6C	ZDLTA_HIGH			R
0x6E	ZDLTA_LOW			R

#### bit[15:0] Delta Angle (Gyroscope) output data

Returns the Delta Angle output format from the 3-axis gyroscope data for X, Y, and Z as referenced in Figure 3.1 Outline Dimensions (millimeters).

The output data format is 32-bits two's complement. For 16-bit usage, treat the data as 16-bits two's complement using the upper 16-bits.

Please refer to **DLT\_RANGE\_CTRL** of **DLT\_CTRL[0x12(W1)] bit[3:0]** for the appropriate delta angle scale factor value.

For 32-bit usage:  $\Delta\text{Angle [deg]} = (\text{SF}/65536) * D$

For 16-bit usage:  $\Delta\text{Angle [deg]} = \text{SF} * D$

SF : Scale Factor \*Refer to **DLT\_RANGE\_CTRL** setting  
D: Gyroscope delta angle output data (decimal)

### 7.14 DELTA\_VELOCITY Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x70	XDLTV_HIGH			R
0x72	XDLTV_LOW			R
0x74	YDLTV_HIGH			R
0x76	YDLTV_LOW			R
0x78	ZDLTV_HIGH			R
0x7A	ZDLTV_LOW			R

#### bit[15:0] Delta Velocity (Acceleration) output data

Returns the Delta Velocity output format from the 3-axis acceleration data for X, Y, and Z as referenced in Figure 3.1 Outline Dimensions (millimeters).

The output data format is 32-bits two's complement. For 16-bit usage, treat the data as 16-bits two's complement using the upper 16-bits.

Please refer to **DLT\_RANGE\_CTRL** of **DLT\_CTRL[0x12(W1)] bit[3:0]** for the appropriate delta velocity scale factor value.

For 32-bit usage:  $\Delta\text{Velocity [m/s]} = (\text{SF}/65536) * E$

For 16-bit usage:  $\Delta\text{Velocity [m/s]} = \text{SF} * E$

SF : Scale Factor \*Refer to **DLT\_RANGE\_CTRL** setting

E: Acceleration delta velocity output data (decimal)

### 7.15 SIG\_CTRL Register (Window 1)

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

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x00	ND_EN (XDLTA)	ND_EN (YDLTA)	ND_EN (ZDLTA)	ND_EN (XDLTV)	ND_EN (YDLTV)	ND_EN (ZDLTV)	-	-	R/W

#### bit[15:9] ND\_EN (Temperature, Gyroscope, Acceleration)

Enables or disables the ND flags in FLAG [0x06(W0)] bit [15:9].

1 :Enable

0 :Disable

#### bit[7:2] ND\_EN (Delta Angle, Delta Velocity)

Enables or disables the ND flags in FLAG [0x06(W0)] bit [7:2].

1 :Enable

0 :Disable

NOTE: **ND\_EN** setting is invalid, when UART automatic mode is active.

## 7.16 MSC\_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x03	-	-	-	-	FLASH_TEST	SELF_TEST	-	-	R/W

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

NOTE: The **FLASH\_TEST**, and **SELF\_TEST** functions can not 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[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] SELF\_TEST

Write “1” to execute the self test to check if the gyroscope and the accelerometer are 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 **ST\_ERR\_ALL** of **DIAG\_STAT** [0x04(W0)] bit 1 to check the results.

### bit[7:6] EXT\_SEL

These bits select the function of GPIO2 terminal to be GPIO2, External Counter Reset Input, or External Trigger Input.

00 :GPIO2

01: External Counter Reset Input

10: External Trigger Input TypeA

11: External Trigger Input TypeB

### bit[2] DRDY\_ON

Selects the function of the GPIO1 terminal for either GPIO1 or Data Ready.

1 : Data Ready Signal

0 : GPIO1

### bit[1] DRDY\_POL

Selects the polarity of the Data Ready signal when selected in **DRDY\_ON** above.

1 :Active High

0 :Active Low

### 7.17 SMPL\_CTRL Register (Window 1)

Addr (Hex)	Bit15	...	Bit8	R/W
0x05	DOUT_RATE			R/W

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

#### bit[15:8] DOUT\_RATE

Specifies the data output rate.

The following lists the data output rate option with the recommended number of filter taps when using the moving average filter.

0x00	:2000Sps	TAP>=0
0x01	:1000Sps	TAP>=0
0x02	:500Sps	TAP>=2
0x03	:250Sps	TAP>=4
0x04	:125Sps	TAP>=8
0x05	:62.5Sps	TAP>=16
0x06	:31.25Sps	TAP>=32
0x07	:15.625Sps	TAP=64
0x08	:400 Sps	TAP>=8
0x09	:200 Sps	TAP>=8
0x0A	:100 Sps	TAP>=16
0x0B	:80 Sps	TAP>=32
0x0C	:50 Sps	TAP>=32
0x0D	:40 Sps	TAP>=32
0x0E	:25 Sps	TAP=64
0x0F	:20 Sps	TAP=64

NOTE: 2000Sps is not supported for SPI normal read mode.

The SET\_ERR bit in DIAG\_STAT[0x05(W0)] bit 10 will indicate an error if an invalid combination (denoted by "x") in output rate setting (SMPL\_CTRL[0x05(W1)] bit[11:8]) and filter setting (FILTER\_CTRL[0x06(W1)] bit[4:0]) is selected as outlined in Table 7.2.

NOTE: When Delta Angle / Delta Velocity is enabled, there is no restriction (SET\_ERR event) on the combination in output rate setting and filter setting.

During a detected SET\_ERR condition, the output registers TEMP\_HIGH~TEMP\_LOW / X\_GYRO\_HIGH~Z\_GYRO\_LOW / X\_ACCL\_HIGH~Z\_ACCL\_LOW will output a fixed value 0x7EF0.

Table 7.2 SET\_ERR Flag Output Rate and Filter Setting Table Evaluation Table  
 ATTI\_CTRL[0x15(W1)]bit[10:9] ATTI\_ON = 00

		Filter TAP Number																			
		0	2	4	8	16	32	64	128	32Fc50	32Fc100	32Fc200	32Fc400	64Fc50	64Fc100	64Fc200	64Fc400	128Fc50	128Fc100	128Fc200	128Fc400
	2000	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	400	-	-	-	OK	OK	OK	OK	OK	OK	OK	-	OK	OK	OK	-	OK	OK	OK	-	-
	80	-	-	-	-	-	OK	OK	OK	-	-	-	-	-	-	-	-	-	-	-	-

		Filter TAP Number																			
		0	2	4	8	16	32	64	128	32Fc25	32Fc50	32Fc100	32Fc200	64Fc25	64Fc50	64Fc100	64Fc200	128Fc25	128Fc50	128Fc100	128Fc200
Data Output Rate	1000	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	500	-	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
	250	-	-	OK	OK	OK	OK	OK	OK	OK	OK	-	OK	OK	OK	-	OK	OK	OK	-	-
	200	-	-	-	OK	OK	OK	OK	OK	OK	OK	-	OK	OK	OK	-	OK	OK	OK	-	-
	125	-	-	-	OK	OK	OK	OK	OK	OK	OK	-	-	OK	OK	-	-	OK	OK	-	-
	100	-	-	-	-	OK	OK	OK	OK	OK	OK	-	-	OK	OK	-	-	OK	OK	-	-
	62.5	-	-	-	-	OK	OK	OK	OK	OK	-	-	-	OK	-	-	-	OK	-	-	-
	50	-	-	-	-	-	OK	OK	OK	OK	-	-	-	OK	-	-	-	OK	-	-	-
	40	-	-	-	-	-	OK	OK	OK	-	-	-	-	-	-	-	-	-	-	-	-
	31.25	-	-	-	-	-	OK	OK	OK	-	-	-	-	-	-	-	-	-	-	-	-
	25	-	-	-	-	-	-	OK	OK	-	-	-	-	-	-	-	-	-	-	-	-
	20	-	-	-	-	-	-	OK	OK	-	-	-	-	-	-	-	-	-	-	-	-
	15.625	-	-	-	-	-	-	OK	OK	-	-	-	-	-	-	-	-	-	-	-	-

“OK”=Supported, “-”=Invalid

NOTE: There are limitations on Delta Angle/Velocity, Range Over, or Run Time Diagnostics functions depending on the output rate as shown in the following table.

Table 7.3 Output Rate Limitations

Output Rate	Gyro [0x12-1D(W0)] Accel [0x1E-29(W0)]	Rotation Matrix [0x38-5B(W1)]	Delta [0x64-0x7B(W0)]	Range Over [0x0C,0x0D(W0)]	Run Time Diag [0x2B(W0)]
2000	OK	-	-	-	-
1000	OK	OK	OK	OK	OK
500	OK	OK	OK	OK	OK
400	OK	-	-	-	-
250	OK	OK	OK	OK	OK
200	OK	OK	OK	OK	OK
125	OK	OK	OK	OK	OK
100	OK	OK	OK	OK	OK
80	OK	-	-	-	-
62.5	OK	OK	OK	OK	OK
50	OK	OK	OK	OK	OK
40	OK	OK	OK	OK	OK
31.25	OK	OK	OK	OK	OK
25	OK	OK	OK	OK	OK
20	OK	OK	OK	OK	OK
15.625	OK	OK	OK	OK	OK

“OK”=Supported, ”-”=Invalid

## 7.18 FILTER\_CTRL Register (Window 1)

Addr (Hex)	Bit15	...	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 completion status of the filter selection. After setting the **FILTER\_SEL** in bits[4:0], this status bit will be set 1. After completion of the filter setting operation, this bit will return to 0.

- 1: Filter setting is busy
- 0: Filter setting is completed

### bit[4:0] FILTER\_SEL

Specifies the type of filter (moving average filter and FIR Kaiser filter) and TAP setting. For the FIR Kaiser filter, these bits also selects the cutoff frequency  $f_c$  in Hz. The  $f_c$  of the Kaiser filter depends on the setting value of **SMPL\_CTRL**[0x05(W1)]. The details are as follows.

After setting the filter with these bits, the completion of the operation requires time period specified in Table 2.4 Filter Setting Time to elapse or confirming completion by checking **FILTER\_STAT** bit 5.

NOTE: Refer to 5.13 Filter for description of filter transient response from sampling start.

- 00000: Moving average filter TAP=0
- 00001: Moving average filter TAP=2
- 00010: Moving average filter TAP=4
- 00011: Moving average filter TAP=8
- 00100: Moving average filter TAP=16
- 00101: Moving average filter TAP=32
- 00110: Moving average filter TAP=64
- 00111: Moving average filter TAP=128

#### ■ **SMPL\_CTRL**[0x05(W1)] = 2000,400,80sps

- 01000 : FIR Kaiser filter (parameter=8) TAP=32,  $f_c$ =50
- 01001 : FIR Kaiser filter (parameter=8) TAP=32,  $f_c$ =100
- 01010 : FIR Kaiser filter (parameter=8) TAP=32,  $f_c$ =200
- 01011 : FIR Kaiser filter (parameter=8) TAP=32,  $f_c$ =400
- 01100 : FIR Kaiser filter (parameter=8) TAP=64,  $f_c$ =50
- 01101 : FIR Kaiser filter (parameter=8) TAP=64,  $f_c$ =100
- 01110 : FIR Kaiser filter (parameter=8) TAP=64,  $f_c$ =200
- 01111 : FIR Kaiser filter (parameter=8) TAP=64,  $f_c$ =400
- 10000 : FIR Kaiser filter (parameter=8) TAP=128,  $f_c$ =50
- 10001 : FIR Kaiser filter (parameter=8) TAP=128,  $f_c$ =100
- 10010 : FIR Kaiser filter (parameter=8) TAP=128,  $f_c$ =200
- 10011 : FIR Kaiser filter (parameter=8) TAP=128,  $f_c$ =400

#### ■ **SMPL\_CTRL**[0x05(W1)] = 1000,500,250,125,62.5,15.625,200,100,50,40,25,20sps

- 01000 : FIR Kaiser filter (parameter=8) TAP=32,  $f_c$ =25

01001 : FIR Kaiser filter (parameter=8) TAP=32、fc=50  
 01010 : FIR Kaiser filter (parameter=8) TAP=32、fc=100  
 01011 : FIR Kaiser filter (parameter=8) TAP=32、fc=200  
 01100 : FIR Kaiser filter (parameter=8) TAP=64、fc=25  
 01101 : FIR Kaiser filter (parameter=8) TAP=64、fc=50  
 01110 : FIR Kaiser filter (parameter=8) TAP=64、fc=100  
 01111 : FIR Kaiser filter (parameter=8) TAP=64、fc=200  
 10000 : FIR Kaiser filter (parameter=8) TAP=128、fc=25  
 10001 : FIR Kaiser filter (parameter=8) TAP=128、fc=50  
 10010 : FIR Kaiser filter (parameter=8) TAP=128、fc=100  
 10011 : FIR Kaiser filter (parameter=8) TAP=128、fc=200  
 10100-11111: Unused

### 7.19 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	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x08	-						AUTO_START	UART_AUTO	R/W

#### bit[9:8] BAUD\_RATE

These bits specifies the Baud Rate of UART interface.

- 00 : 460.8kbps
- 01 : 230.4kbps
- 10 : 921.6kbps

NOTE: The baud rate change using these **BAUD\_RATE** bits become effective immediately after write access completes.

#### bit[1] AUTO\_START (Only valid for UART Auto Mode)

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 when IMU is powered on or reset.

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 mode function.

NOTE: This register bit must be set to 0 when using the SPI interface.

- 1 :UART automatic mode is selected
- 0 :UART manual mode is selected

If UART automatic mode is active, register values such as FLAG, temperature, angle rate (XGYRO, YGYRO, ZGYRO), accelerations (XACCL, YACCL, ZACCL), and others are continuously transmitted automatically according to the data output rate set by SMPL\_CTRL [0x04(W1)] register.

In UART manual mode, register data is transmitted as a response to a register read command.

NOTE: For more info on UART Auto Mode refer to 6.2.4 UART Auto Mode Operation and 6.3 Data Packet Format. The burst output data is configured by register setting in BURST\_CTRL1 [0x0C(W1)]

and BURST\_CTRL2 [0x0E(W1)].



## 7.20 GLOB\_CMD Register (Window 1)

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

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

### bit[10] NOT\_READY

Indicates whether the IMU is currently ready. Immediately after power on, this bit is “1” and becomes “0” when the IMU 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[4] INITIAL\_BACKUP

Write “1” to set the non-volatile memory for the registers with ○ in the “Flash Backup” column in Table 7.1 to the factory default value. This bit automatically returns to “0” after execution is completed. The factory default value is reflected in the registers after power on or after a hardware or software reset.

### bit[3] FLASH\_BACKUP

Write “1” to save the current values of the control registers with the ○ 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.

## 7.21 BURST\_CTRL1 Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x0D	FLAG_OUT	TEMP_OUT	GYRO_OUT	ACCL_OUT	DLTA_OUT	DLTV_OUT	-	-	R/W

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

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

### bit[15] FLAG\_OUT

Controls the output of FLAG status.

- 1 :Enables output.
- 0 :Disables output.

### bit[14] TEMP\_OUT

Controls the output of temperature sensor.

- 1 :Enables output.
- 0 :Disables output.

### bit[13] GYRO\_OUT

Controls the output of gyroscope sensor.

- 1 :Enables output.
- 0 :Disables output.

### bit[12] ACCL\_OUT

Controls the output of acceleration sensor.

- 1 :Enables output.
- 0 :Disables output.

### bit[11] DLTA\_OUT

Controls the output of delta angle.

- 1 :Enables output.
- 0 :Disables output.

### bit[10] DLTV\_OUT

Controls the output of delta velocity.

- 1 :Enables output.
- 0 :Disables output.

### bit[2] GPIO\_OUT

Controls the output of GPIO status.

- 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.

## 7.22 BURST\_CTRL2 Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x0F	-	TEMP_BIT	GYRO_BIT	ACCL_BIT	DLTA_BIT	DLTV_BIT	-	-	R/W
Addr (Hex)	Bit7	...						Bit0	R/W
0x0E	-							-	-

These bits select the output bit length of output data for burst mode and UART Auto mode.

### bit[14] TEMP\_BIT

Selects the bit length of the temperature output.

- 1 : 32-bit
- 0 : 16-bit

### bit[13] GYRO\_BIT

Selects the bit length of the gyroscope output.

- 1 : 32-bit
- 0 : 16-bit

### bit[12] ACCL\_BIT

Selects the bit length of the acceleration output.

- 1 : 32-bit
- 0 : 16-bit

### bit[11] DLTA\_BIT

Selects the bit length of the delta angle output.

- 1 : 32-bit
- 0 : 16-bit

### bit[10] DLTV\_BIT

Selects the bit length of the delta velocity output.

- 1 : 32-bit
- 0 : 16-bit

## 7.23 POL\_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x11	-								R/W
Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x10	-	POL_CTRL (XGyro)	POL_CTRL (YGyro)	POL_CTRL (ZGyro)	POL_CTRL (XACCL)	POL_CTRL (YACCL)	POL_CTRL (ZACCL)	-	R/W

### bit[6:1] POL\_CTRL

Specifies whether to bitwise invert the output value of the following registers: angular rate (**XGYRO**, **YGYRO**, **ZGYRO**) and acceleration (**XACCL**, **YACCL**, **ZACCL**). This bitwise inversion will also have effect in the internal processing for the delta angle (**DLTA**, **YDLTA**, **ZDLTA**), and delta velocity (**DLTV**, **YDLTV**, **ZDLTV**).

- 1 : Inverted
- 0 : Not inverted

## 7.24 DLT\_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W
0x13	-								R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x12	DLTA_RANGE_CTRL				DLTV_RANGE_CTRL				R/W

### bit[7:4] DLTA\_RANGE\_CTRL

These bits specifies the scale factor and range of Delta Angle output.

NOTE: The user must carefully select the desired scale factor to optimize Delta Angle resolution but avoid an overflow condition in the internal Delta Angle processing.

### bit[3:0] DLTV\_RANGE\_CTRL

These bits specifies the scale factor and range of Delta Velocity output.

NOTE: The user must carefully select the desired scale factor to optimize Delta Velocity resolution but avoid an overflow condition in the internal Delta Velocity processing.

Table 7.4 Delta Angle : Scale Factor & Range

bit[3:0]	Scale Factor *1 [deg/LSB]	Range *1 [+/- deg]
0000	6.667.E-06	2.185E-01
0001	1.333.E-05	4.369E-01
0010	2.667.E-05	8.738E-01
0011	5.333.E-05	1.748E+00
0100	1.067.E-04	3.495E+00
0101	2.133.E-04	6.991E+00
0110	4.267.E-04	1.398E+01
0111	8.533.E-04	2.796E+01
1000	1.707.E-03	5.592E+01
1001	3.413.E-03	1.118E+02
1010	6.827.E-03	2.237E+02
1011	1.365.E-02	4.474E+02
1100	2.731.E-02	8.948E+02
1101	5.461.E-02	1.790E+03
1110	1.092.E-01	3.579E+03
1111	2.185.E-01	7.158E+03

\*1 Scale Factor and Range : 16bit

Table 7.5 Delta Velocity : Scale Factor & Range

bit[3:0]	Scale Factor *1 [(m/s)/LSB]	Range *1 [+/- (m/s)]
0000	3.923.E-06	1.285E-01
0001	7.845.E-06	2.571E-01
0010	1.569.E-05	5.142E-01
0011	3.138.E-05	1.028E+00
0100	6.276.E-05	2.057E+00
0101	1.255.E-04	4.113E+00
0110	2.511.E-04	8.226E+00
0111	5.021.E-04	1.645E+01
1000	1.004.E-03	3.291E+01
1001	2.008.E-03	6.581E+01
1010	4.017.E-03	1.316E+02
1011	8.034.E-03	2.632E+02
1100	1.607.E-02	5.265E+02
1101	3.213.E-02	1.053E+03
1110	6.427.E-02	2.106E+03
1111	1.285.E-01	4.212E+03

\*1) Scale Factor and Range: 16bit



## 7.25 ATTI\_CTRL Register (Window 1)

Addr (Hex)	Bit15	Bit14	Bit13	Bit12	Bit11	Bit10	Bit9	Bit8	R/W	
0x15	-						ATTI_ON			R/W

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x14	-								R/W

### bit[10:9] ATTI\_ON

This bit enables or disables the Delta Angle/Delta Velocity output.

00 : Disable

01 : Delta Angle/ Delta Velocity Output

10 ~ 11: Invalid

NOTE: ATTI\_ON=01 has limitations when used with external trigger input as described in Table 5.9

NOTE: Delta Angle/ Delta Velocity Output rate has limitations as described in Table 7.3

## 7.26 GLOB\_CMD2 Register (Window 1)

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

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

### bit[9] INITIAL\_ROTATION\_BACKUP

Write "1" to set the non-volatile memory for the R\_MATRIX registers with ○ in the "Flash Backup" column in Table 7.1 to the factory default value. This bit automatically returns to "0" after execution is completed. The factory default value is reflected in the registers after power on or after a hardware or software reset.

### bit[8] FLASH\_ROTATION\_BACKUP

Write "1" to save the current values of the R\_MATRIX registers with the ○ 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", check the result in FLASH\_BU\_ERR of DIAG\_STAT [0x04(W0)] bit 0.

## 7.27 R\_MATRIX Register (Window 1)

Addr (Hex)	Bit15	...	Bit0	R/W
0x38		R_MATRIX_G_M11		R/W
0x3A		R_MATRIX_G_M12		R/W
0x3C		R_MATRIX_G_M13		R/W
0x3E		R_MATRIX_G_M21		R/W
0x40		R_MATRIX_G_M22		R/W
0x42		R_MATRIX_G_M23		R/W
0x44		R_MATRIX_G_M31		R/W
0x46		R_MATRIX_G_M32		R/W
0x48		R_MATRIX_G_M33		R/W
0x4A		R_MATRIX_A_M11		R/W
0x4C		R_MATRIX_A_M12		R/W
0x4E		R_MATRIX_A_M13		R/W
0x50		R_MATRIX_A_M21		R/W
0x52		R_MATRIX_A_M22		R/W
0x54		R_MATRIX_A_M23		R/W
0x56		R_MATRIX_A_M31		R/W
0x58		R_MATRIX_A_M32		R/W
0x5A		R_MATRIX_A_M33		R/W

### bit[15:0] Rotation Matrix Coefficient

The frame alignment of gyroscope triad and acceleration sensor triad can be corrected by using the R\_MATRIX function. Refer to 5.16 Frame Alignment Correction for more details.

## 7.28 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

These registers return the product model number represented in ASCII code.  
For example, Product ID return value is G370PDS0.

PROD\_ID1:0x3347

PROD\_ID2:0x3037

PROD\_ID3:0x4450

PROD\_ID4:0x3053

## 7.29 VERSION Register (Window 1)

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

### bit[15:0] Version

This register returns the Firmware Version

## 7.30 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

These registers return the serial number represented in ASCII code.

NOTE: SERIAL\_NUM1[7:0] is fixed and always returns 0x31 or "1" (ASCII).

For example, if the Serial Number is 11234567 then the return value is:

SERIAL\_NUM1:0x3131

SERIAL\_NUM2:0x3332

SERIAL\_NUM3:0x3534

SERIAL\_NUM4:0x3736

### 7.31 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**

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

0x00 :Window 0

0x01 :Window 1

0x02-0xFF: Unused



## 8. Sample Program Sequence

The following describes the recommended procedures for operating this device.

### 8.1 SPI Sequence

#### 8.1.1 Power-on sequence (SPI)

Power-on sequence is as follows.

(a) power-on.

(b) Wait 800ms.

(c) Wait until NOT\_READY bit goes to 0. NOT\_READY is GLOB\_CMD[0x0A(W1)]'s bit[10].

TXdata={0xFE01}/ RXdata={0x----}. /\* WINDOW=1 \*/

TXdata={0x0A00}/ RXdata={0x----}. /\* GLOB\_CMD read command \*/

TXdata={0x0000}/ RXdata={GLOB\_CMD}. /\* 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[6:5].

TXdata={0xFE00}/ RXdata={0x----}. /\* WINDOW\_ID write command.(WINDOW=0) \*/

TXdata={0x0400}/ RXdata={0x----}. /\* DIAG\_STAT read command \*/

TXdata={0x0000}/ RXdata={DIAG\_STAT}. /\* get response \*/

Confirm HARD\_ERR is 00.

If HARD\_ERR is 00, the IMU is OK. Otherwise, the IMU is faulty.

-.don't care

#### 8.1.2 Register read and write (SPI)

[Read Example]

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

TXdata={0xFE00}/ RXdata={0x----}. /\* WINDOW=0 \*/

TXdata={0x0200}/ RXdata={0x----}. /\* read command \*/

TXdata={0x----}/ RXdata={0x0400}. /\* get response \*/

-.don't care

0x04 in high byte of RXdata is Configuration mode.

0x00 in low byte of RXdata is Reserved.

Please note that read data unit is 16bit, and Most Significant Bit first in 16bit SPI.

[Write Example]

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

TXdata={0xFE00}/ RXdata={0x----}. /\* WINDOW=0 \*/

TXdata={0x8301}/ RXdata={0x----}. /\* write command \*/

There is no response at Write.

-.don't care

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

Please note that write data unit is 8bit.

#### 8.1.3 Sampling data (SPI)

[Sample Flow 1 (SPI normal mode)]

Power-on sequence. Please refer to Chapter 8.1.1.

Filter setting sequence. Please refer to Chapter 8.1.8.

```

TXdata={0xFE01}/ RXdata={0x----}.      /* WINDOW=1 */
TXdata={0x8504}/ RXdata={0x----}.      /* 125SPS */
TXdata={0x8604}/ RXdata={0x----}.      /* TAP = 16*/
TXdata={0x8800}/ RXdata={0x----}.      /* disable UART auto mode, just in case. */
TXdata={0xFE00}/ RXdata={0x----}.      /* WINDOW=0 */
TXdata={0x8301}/ RXdata={0x----}.      /* move to Sampling mode */
receive sampling data.
(a)Wait until Data Ready signal is asserted.
(b)
TXdata={0x0600}/ RXdata={0x----}.      /* FLAG read command */
TXdata={0x0E00}/ RXdata={FLAG}.        /* TEMP_HIGH read command */
TXdata={0x1000}/ RXdata={TEMP_HIGH}.   /* TEMP_LOW read command */
TXdata={0x1200}/ RXdata={TEMP_LOW}.    /* XGYRO_HIGH read command */
TXdata={0x1400}/ RXdata={XGYRO_HIGH}.  /* XGYRO_LOW read command */
TXdata={0x1600}/ RXdata={XGYRO_LOW}.   /* YGYRO_HIGH read command */
TXdata={0x1800}/ RXdata={YGYRO_HIGH}.  /* YGYRO_LOW read command */
TXdata={0x1A00}/ RXdata={YGYRO_LOW}.   /* ZGYRO_HIGH read command */
TXdata={0x1C00}/ RXdata={ZGYRO_HIGH}.  /* ZGYRO_LOW read command */
TXdata={0x1E00}/ RXdata={ZGYRO_LOW}.   /* XACCL_HIGH read command */
TXdata={0x2000}/ RXdata={XACCL_HIGH}.   /* XACCL_LOW read command */
TXdata={0x2200}/ RXdata={XACCL_LOW}.   /* YACCL_HIGH read command */
TXdata={0x2400}/ RXdata={YACCL_HIGH}.   /* YACCL_LOW read command */
TXdata={0x2600}/ RXdata={YACCL_LOW}.   /* ZACCL_HIGH read command */
TXdata={0x2800}/ RXdata={ZACCL_HIGH}.  /* ZACCL_LOW read command */
TXdata={0x0800}/ RXdata={ZACCL_LOW}.   /* GPIO read command */
TXdata={0x0A00}/ RXdata={GPIO}.        /* COUNT read command */
TXdata={0x----}/ RXdata={COUNT}.
repeat from (a) to (b).
TXdata={0x8302}/ RXdata={0x----}.      /* return to Configuration mode */

```

-.don't care

#### notes

Please remember to wait until Data Ready signal is asserted.

#### [Sample Flow 2 (SPI normal mode)]

To read upper 16 bits data of temperature, gyroscope and accelerometer.

Power-on sequence. Please refer to Chapter 8.1.1.

Filter setting sequence. Please refer to Chapter 8.1.8.

```

TXdata={0xFE01}/ RXdata={0x----}.      /* WINDOW=1 */
TXdata={0x8504}/ RXdata={0x----}.      /* 125SPS */
TXdata={0x8604}/ RXdata={0x----}.      /* TAP=16*/
TXdata={0x8800}/ RXdata={0x----}.      /* disable UART auto mode, just in case. */
TXdata={0xFE00}/ RXdata={0x----}.      /* WINDOW=0 */
TXdata={0x8301}/ RXdata={0x----}.      /* move to Sampling mode */
receive sampling data.
(a)Wait until Data Ready signal is asserted.
(b)
TXdata={0x0600}/ RXdata={0x----}.      /* FLAG read command */
TXdata={0x0E00}/ RXdata={FLAG}.        /* TEMP_HIGH read command */
TXdata={0x1200}/ RXdata={TEMP_HIGH}.   /* XGYRO_HIGH read command */
TXdata={0x1600}/ RXdata={XGYRO_HIGH}.  /* YGYRO_HIGH read command */
TXdata={0x1A00}/ RXdata={YGYRO_HIGH}.  /* ZGYRO_HIGH read command */
TXdata={0x1E00}/ RXdata={ZGYRO_HIGH}.  /* XACCL_HIGH read command */
TXdata={0x2200}/ RXdata={XACCL_HIGH}.  /* YACCL_HIGH read command */
TXdata={0x2600}/ RXdata={YACCL_HIGH}.  /* ZACCL_HIGH read command */

```

```

TXdata={0x0800}/ RXdata={ZACCL_HIGH}.           /* GPIO read command */
TXdata={0x0A00}/ RXdata={GPIO}.                 /* COUNT read command */
TXdata={0x----}/ RXdata={COUNT}.
repeat from (a) to (b).
TXdata={0x8302}/ RXdata={0x----}.             /* return to Configuration mode */

```

-.:don't care

notes

Please remember to wait until Data Ready signal is asserted.

[Sample Flow 3 (SPI burst mode)]

Power-on sequence. Please refer to Chapter 8.1.1.

Filter setting sequence. Please refer to Chapter 8.1.8.

```

TXdata={0xFE01}/ RXdata={0x----}.             /* WINDOW=1 */
TXdata={0x8504}/ RXdata={0x----}.             /* 125SPS */
TXdata={0x8604}/ RXdata={0x----}.             /* TAP=16 */
TXdata={0x8800}/ RXdata={0x----}.             /* disable UART auto mode, just in case. */
TXdata={0x8C06}/ RXdata={0x----}.             /* GPIO=on,COUNT=on,CheckSum=off */
TXdata={0x8DF0}/ RXdata={0x----}.             /* FLAG=on,TEMP=on,Gyro=on,ACCL=on */
TXdata={0x8F70}/ RXdata={0x----}.             /* TEMP=32bit,Gyro=32bit,ACCL=32bit */
TXdata={0xFE00}/ RXdata={0x----}.             /* WINDOW=0 */
TXdata={0x8301}/ RXdata={0x----}.             /* move to Sampling mode */

```

receive sampling data.

(a)Wait until Data Ready signal is asserted.

(b)

```

TXdata={0x8000}/ RXdata={0x----}.             /* BURST command */
TXdata={0x----}/ RXdata={FLAG}.
TXdata={0x----}/ RXdata={TEMP_HIGH}.
TXdata={0x----}/ RXdata={TEMP_LOW}.
TXdata={0x----}/ RXdata={XGYRO_HIGH}.
TXdata={0x----}/ RXdata={XGYRO_LOW}.
TXdata={0x----}/ RXdata={YGYRO_HIGH}.
TXdata={0x----}/ RXdata={YGYRO_LOW}.
TXdata={0x----}/ RXdata={ZGYRO_HIGH}.
TXdata={0x----}/ RXdata={ZGYRO_LOW}.
TXdata={0x----}/ RXdata={XACCL_HIGH}.
TXdata={0x----}/ RXdata={XACCL_LOW}.
TXdata={0x----}/ RXdata={YACCL_HIGH}.
TXdata={0x----}/ RXdata={YACCL_LOW}.
TXdata={0x----}/ RXdata={ZACCL_HIGH}.
TXdata={0x----}/ RXdata={ZACCL_LOW}.
TXdata={0x----}/ RXdata={GPIO}.
TXdata={0x----}/ RXdata={COUNT}.
repeat from (a) to (b).
TXdata={0x8302}/ RXdata={0x----}.             /* return to Configuration mode */

```

-.:don't care

notes

Please remember to wait until Data Ready signal is asserted.

[Sample Flow 4 (SPI burst mode)]

To read upper 16 bits data of temperature, gyroscope and accelerometer.

Power-on sequence. Please refer to Chapter 8.1.1.

Filter setting sequence. Please refer to Chapter 8.1.8.

```

TXdata={0xFE01}/ RXdata={0x----}.      /* WINDOW=1 */
TXdata={0x8504}/ RXdata={0x----}.      /* 125SPS */
TXdata={0x8604}/ RXdata={0x----}.      /* TAP=16 */
TXdata={0x8800}/ RXdata={0x----}.      /* disable UART auto mode, just in case. */
TXdata={0x8C06}/ RXdata={0x----}.      /* GPIO=on,COUNT=on,CheckSum=off */
TXdata={0x8DF0}/ RXdata={0x----}.      /* FLAG=on,TEMP=on,Gyro=on,ACCL=on */
TXdata={0x8F00}/ RXdata={0x----}.      /* TEMP=16bit,Gyro=16bit,ACCL=16bit */
TXdata={0xFE00}/ RXdata={0x----}.      /* WINDOW=0 */
TXdata={0x8301}/ RXdata={0x----}.      /* move to Sampling mode */

```

receive sampling data.

(a) Wait until Data Ready signal is asserted.

(b)

```

TXdata={0x8000}/ RXdata={0x----}.      /* BURST command */
TXdata={0x----}/ RXdata={FLAG}.
TXdata={0x----}/ RXdata={TEMP_HIGH}.
TXdata={0x----}/ RXdata={XGYRO_HIGH}.
TXdata={0x----}/ RXdata={YGYRO_HIGH}.
TXdata={0x----}/ RXdata={ZGYRO_HIGH}.
TXdata={0x----}/ RXdata={XACCL_HIGH}.
TXdata={0x----}/ RXdata={YACCL_HIGH}.
TXdata={0x----}/ RXdata={ZACCL_HIGH}.
TXdata={0x----}/ RXdata={GPIO}.
TXdata={0x----}/ RXdata={COUNT}.

```

repeat from (a) to (b).

```

TXdata={0x8302}/ RXdata={0x----}.      /* return to Configuration mode */

```

-:don't care

notes

Please remember to wait until Data Ready signal is asserted.

#### 8.1.4 Selftest (SPI)

Selftest is as follows.

Power-on sequence. Please refer to Chapter 8.1.1.

(a) Send self test command.

```

TXdata={0xFE01}/ RXdata={0x----}.      /* WINDOW=1 */
TXdata={0x8304}/ RXdata={0x----}.      /* Selftest command */

```

(b) Wait until selftest has finished.

Wait until SELF\_TEST bit goes to 0. SELF\_TEST is MSC\_CTRL[0x02(W1)]'s bit[10].

```

TXdata={0x0200}/ RXdata={0x----}.      /* MSC_CTRL read command */
TXdata={0x0000}/ RXdata={MSC_CTRL}.    /* get response */

```

Confirm SELF\_TEST bit.

When SELF\_TEST becomes 0, it ends. Otherwise, please repeat (b).

(c) Confirm the result.

Confirm ST\_ERR bits. ST\_ERR is DIAG\_STAT[0x04(W0)]'s bit[14:11].

```

TXdata={0xFE00}/ RXdata={0x----}.      /* WINDOW=0 */
TXdata={0x0400}/ RXdata={0x----}.      /* DIAG_STAT read command */
TXdata={0x0000}/ RXdata={DIAG_STAT}.   /* get response */

```

Confirm each ST\_ERR is 0.

If each ST\_ERR is 0, the result is OK. Otherwise, the result is NG.

-:don't care

### 8.1.5 Software Reset (SPI)

Software reset is as follows.

Power-on sequence. Please refer to Chapter 8.1.1.

(a) Send software reset command.

TXdata={0xFE01}/ RXdata={0x----}. /\* WINDOW=1 \*/  
 TXdata={0x8A80}/ RXdata={0x----}. /\* Software reset command \*/

(b) Wait 800ms.

-:don't care

### 8.1.6 Flash Test (SPI)

Flash test is as follows.

Power-on sequence. Please refer to Chapter 8.1.1.

(a) Send flash test command.

TXdata={0xFE01}/ RXdata={0x----}. /\* WINDOW=1 \*/  
 TXdata={0x8308}/ RXdata={0x----}. /\* Flash test command \*/

(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={0x0200}/ RXdata={0x----}. /\* MSC\_CTRL read command \*/  
 TXdata={0x0000}/ RXdata={MSC\_CTRL}. /\* 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={0xFE00}/ RXdata={0x----}. /\* WINDOW=0 \*/  
 TXdata={0x0400}/ RXdata={0x----}. /\* DIAG\_STAT read command \*/  
 TXdata={0x0000}/ RXdata={DIAG\_STAT}. /\* get response \*/

Confirm FLASH\_ERR is 0.

If FLASH\_ERR is 0, the result is OK. Otherwise, the result is NG.

-:don't care

### 8.1.7 Flash Backup (SPI)

Flash backup is as follows.

Power-on sequence. Please refer to Chapter 8.1.1.

(a) Send flash backup command.

TXdata={0xFE01}/ RXdata={0x----}. /\* WINDOW=1 \*/  
 TXdata={0x8A08}/ RXdata={0x----}. /\* Flash backup command \*/

(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={0x0A00}/ RXdata={0x----}. /\* GLOB\_CMD read command \*/  
 TXdata={0x0000}/ RXdata={GLOB\_CMD}. /\* get response \*/

Confirm FLASH\_BACKUP bit.

When FLASH\_BACKUP becomes 0, it ends. Otherwise , please repeat (b).

(c) Confirm the result.

TXdata={0xFE00}/ RXdata={0x----}. /\* WINDOW=0 \*/

Confirm FLASH\_BU\_ERR bits. FLASH\_BU\_ERR is DIAG\_STAT[0x04(W0)]'s bit[0].  
 TXdata={0x0400}/ RXdata={0x----}. /\* DIAG\_STAT read command \*/  
 TXdata={0x0000}/ RXdata={DIAG\_STAT}. /\* get response \*/  
 Confirm FLASH\_BU\_ERR is 0.  
 If FLASH\_BU\_ERR is 0, the result is OK. Otherwise, the result is NG.  
 -:don't care

### 8.1.8 Filter setting (SPI)

Filter setting is as follows.

Power-on sequence. Please refer to Chapter 8.1.1.

(a) Send filter setting command for moving average filter and TAP32.

TXdata={0xFE01}/ RXdata={0x----}. /\* WINDOW=1 \*/  
 TXdata={0x8605}/ RXdata={0x----}. /\* Filter setting command \*/

(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={0x0600}/ RXdata={0x----}. /\* FILTER\_CTRL read command \*/  
 TXdata={0x0000}/ RXdata={FILTER\_CTRL}. /\* get response \*/

Confirm FILTER\_STAT bit.

When FILTER\_STAT becomes 0, it ends. Otherwise, please repeat (b).

### 8.1.9 Frame Alignment Correction (SPI)

[Sample Flow 1 (SPI normal mode)]

Rotate -30 degrees around y-axis

Gyro sensor axis

TXdata={0xB86C}/ RXdata={0x----}. /\* R\_MATRIX\_G\_M11 = 0.866 \*/  
 TXdata={0xB937}/ RXdata={0x----}.  
 TXdata={0xBA00}/ RXdata={0x----}. /\* R\_MATRIX\_G\_M12 = 0 \*/  
 TXdata={0xBB00}/ RXdata={0x----}.  
 TXdata={0xBCFF}/ RXdata={0x----}. /\* R\_MATRIX\_G\_M13 = 0.5 \*/  
 TXdata={0xBD1F}/ RXdata={0x----}.  
 TXdata={0xBE00}/ RXdata={0x----}. /\* R\_MATRIX\_G\_M21 = 0 \*/  
 TXdata={0xBF00}/ RXdata={0x----}.  
 TXdata={0xC000}/ RXdata={0x----}. /\* R\_MATRIX\_G\_M22 = 1 \*/  
 TXdata={0xC140}/ RXdata={0x----}.  
 TXdata={0xC200}/ RXdata={0x----}. /\* R\_MATRIX\_G\_M23 = 0 \*/  
 TXdata={0xC300}/ RXdata={0x----}.  
 TXdata={0xC400}/ RXdata={0x----}. /\* R\_MATRIX\_G\_M31 = - 0.5 \*/  
 TXdata={0xC5E0}/ RXdata={0x----}.  
 TXdata={0xC600}/ RXdata={0x----}. /\* R\_MATRIX\_G\_M32 = 0 \*/  
 TXdata={0xC700}/ RXdata={0x----}.  
 TXdata={0xC86C}/ RXdata={0x----}. /\* R\_MATRIX\_G\_M33 = 0.866 \*/  
 TXdata={0xC937}/ RXdata={0x----}.

Acceleration sensor axis

TXdata={0xCA6C}/ RXdata={0x----}. /\* R\_MATRIX\_A\_M11 = 0.866 \*/  
 TXdata={0xCB37}/ RXdata={0x----}.  
 TXdata={0xCC00}/ RXdata={0x----}. /\* R\_MATRIX\_A\_M12 = 0 \*/  
 TXdata={0xCD00}/ RXdata={0x----}.  
 TXdata={0xCEFF}/ RXdata={0x----}. /\* R\_MATRIX\_A\_M13 = 0.5 \*/  
 TXdata={0xCF1F}/ RXdata={0x----}.  
 TXdata={0xD000}/ RXdata={0x----}. /\* R\_MATRIX\_A\_M21 = 0 \*/

```

TXdata={0xD100}/ RXdata={0x----}.
TXdata={0xD200}/ RXdata={0x----}.      /* R_MATRIX_A_M22 =1      */
TXdata={0xD340}/ RXdata={0x----}.
TXdata={0xD400}/ RXdata={0x----}.      /* R_MATRIX_A_M23= 0      */
TXdata={0xD500}/ RXdata={0x----}.
TXdata={0xD600}/ RXdata={0x----}.      /* R_MATRIX_A_M31 = - 0.5  */
TXdata={0xD7E0}/ RXdata={0x----}.
TXdata={0xD800}/ RXdata={0x----}.      /* R_MATRIX_A_M32 = 0      */
TXdata={0xD900}/ RXdata={0x----}.
TXdata={0xDA6C}/ RXdata={0x----}.      /* R_MATRIX_A_M33 = 0.866  */
TXdata={0xDB37}/ RXdata={0x----}.

```

## 8.2 UART Sequence

### 8.2.1 Power-on sequence (UART)

Power-on sequence is as follows.

(a) power-on.

(b) Wait 800ms.

(c) Wait until NOT\_READY bit goes to 0. NOT\_READY is GLOB\_CMD[0x0A(W1)]'s bit[10].

```

TXdata={0xFE,0x01,0x0d}.      /* WINDOW=1 */
TXdata={0x0A,0x00,0x0d}.      /* GLOB_CMD read command */
RXdata={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[6:5].

```

TXdata={0xFE,0x00,0x0d}.      /* WINDOW=0 */
TXdata={0x04,0x00,0x0d}.      /* DIAG_STAT read command */
RXdata={0x04,MSByte,LSByte,0x0d}. /* get response */
Confirm HARD_ERR is 00.

```

If HARD\_ERR is 00, the IMU is OK. Otherwise, the IMU is faulty.

### 8.2.2 Register read and write (UART)

[Read Example]

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

```

TXdata={0xFE,0x00,0x0d}.      /* WINDOW=0 */
TXdata={0x02,0x00,0x0d}.      /* command */
RXdata={0x02,0x04,0x00,0x0d}   /* 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=0 */
TXdata={0x83,0x01,0x0d}.      /* command */
RXdata= w/o response

```

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

Please note that write data unit is 8bit.

### 8.2.3 Sampling data (UART)

[Sample Flow 1 (UART auto mode)]

Power-on sequence. Please refer to Chapter 8.2.1.

Filter setting sequence. Please refer to Chapter 8.2.8.

```
TXdata={0xFE,0x01,0x0d}. /* WINDOW=1 */
TXdata={0x85,0x04,0x0d}. /* 125SPS */
TXdata={0x86,0x04,0x0d}. /* TAP=16 */
TXdata={0x88,0x01,0x0d}. /* UART Auto mode */
TXdata={0x8C,0x06,0x0d}. /* GPIO=on,COUNT=on,CheckSum=off */
TXdata={0x8D,0xF0,0x0d}. /* FLAG=on,TEMP=on,Gyro=on,ACCL=on */
TXdata={0x8F,0x70,0x0d}. /* TEMP=32bit,Gyro=32bit,ACCL=32bit */
TXdata={0xFE,0x00,0x0d}. /* WINDOW=0 */
TXdata={0x83,0x01,0x0d}. /* move to Sampling mode */
```

receive sampling data.

```
(a)RXdata={0x80, FLAG_Hi, FLAG_Lo,
TEMP_HIGH_Hi, TEMP_HIGH_Lo, TEMP_LOW_Hi, TEMP_LOW_Lo,
XGYRO_HIGH_Hi, XGYRO_HIGH_Lo, XGYRO_LOW_Hi, XGYRO_LOW_Lo,
YGYRO_HIGH_Hi, YGYRO_HIGH_Lo, YGYRO_LOW_Hi, YGYRO_LOW_Lo,
ZGYRO_HIGH_Hi, ZGYRO_HIGH_Lo, ZGYRO_LOW_Hi, ZGYRO_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,
GPIO_Hi, GPIO_Lo, COUNT_Hi, COUNT_Lo, 0x0d}
```

repeat (a).

```
TXdata={0x83,0x02,0x0d}. /* return to Configuration mode */
```

[Sample Flow 2 (UART auto mode)]

To read upper 16 bits data of temperature, gyroscope and accelerometer.

Power-on sequence. Please refer to Chapter 8.2.1.

Filter setting sequence. Please refer to Chapter 8.2.8.

```
TXdata={0xFE,0x01,0x0d}. /* WINDOW=1 */
TXdata={0x85,0x04,0x0d}. /* 125SPS */
TXdata={0x86,0x04,0x0d}. /* TAP=16 */
TXdata={0x88,0x01,0x0d}. /* UART Auto mode */
TXdata={0x8C,0x06,0x0d}. /* GPIO=on,COUNT=on,CheckSum=off */
TXdata={0x8D,0xF0,0x0d}. /* FLAG=on,TEMP=on,Gyro=on,ACCL=on */
TXdata={0x8F,0x00,0x0d}. /* TEMP=16bit,Gyro=16bit,ACCL=16bit */
TXdata={0xFE,0x00,0x0d}. /* WINDOW=0 */
TXdata={0x83,0x01,0x0d}. /* move to Sampling mode */
```

receive sampling data.

```
(a)RXdata={0x80, FLAG_Hi, FLAG_Lo,
TEMP_HIGH_Hi, TEMP_HIGH_Lo,
XGYRO_HIGH_Hi, XGYRO_HIGH_Lo,
YGYRO_HIGH_Hi, YGYRO_HIGH_Lo,
ZGYRO_HIGH_Hi, ZGYRO_HIGH_Lo,
XACCL_HIGH_Hi, XACCL_HIGH_Lo,
YACCL_HIGH_Hi, YACCL_HIGH_Lo,
ZACCL_HIGH_Hi, ZACCL_HIGH_Lo,
GPIO_Hi, GPIO_Lo, COUNT_Hi, COUNT_Lo, 0x0d}
```

repeat (a).

```
TXdata={0x83,0x02,0x0d}. /* return to Configuration mode */
```

[Sample Flow 3 (UART burst mode)]

Power-on sequence. Please refer to Chapter 8.2.1.

Filter setting sequence. Please refer to Chapter 8.2.8.

```
TXdata={0xFE,0x01,0x0d}. /* WINDOW=1 */
TXdata={0x85,0x04,0x0d}. /* 125SPS */
TXdata={0x86,0x04,0x0d}. /* TAP=16 */
TXdata={0x88,0x00,0x0d}. /* UART Manual mode */
TXdata={0x8C,0x06,0x0d}. /* GPIO=on,COUNT=on,CheckSum=off */
TXdata={0x8D,0xF0,0x0d}. /* FLAG=on,TEMP=on,Gyro=on,ACCL=on */
TXdata={0x8F,0x70,0x0d}. /* TEMP=32bit,Gyro=32bit,ACCL=32bit */
TXdata={0xFE,0x00,0x0d}. /* WINDOW=0 */
TXdata={0x83,0x01,0x0d}. /* move to Sampling mode */
```

receive sampling data.

(a)Wait until Data Ready signal is asserted.

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

(c)RXdata={0x80, FLAG\_Hi, FLAG\_Lo,  
TEMP\_HIGH\_Hi, TEMP\_HIGH\_Lo, TEMP\_LOW\_Hi, TEMP\_LOW\_Lo,  
XGYRO\_HIGH\_Hi, XGYRO\_HIGH\_Lo, XGYRO\_LOW\_Hi, XGYRO\_LOW\_Lo,  
YGYRO\_HIGH\_Hi, YGYRO\_HIGH\_Lo, YGYRO\_LOW\_Hi, YGYRO\_LOW\_Lo,  
ZGYRO\_HIGH\_Hi, ZGYRO\_HIGH\_Lo, ZGYRO\_LOW\_Hi, ZGYRO\_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,  
GPIO\_Hi, GPIO\_Lo, COUNT\_Hi, COUNT\_Lo, 0x0d}

repeat from (a) to (c).

TXdata={0x83,0x02,0x0d}. /\* return to Configuration mode \*/

notes

Please remember to wait until Data Ready signal is asserted.

[Sample Flow 4 (UART burst mode)]

To read upper 16 bits data of temperature, gyroscope and accelerometer.

Power-on sequence. Please refer to Chapter 8.2.1.

Filter setting sequence. Please refer to Chapter 8.2.8.

```
TXdata={0xFE,0x01,0x0d}. /* WINDOW=1 */
TXdata={0x85,0x04,0x0d}. /* 125SPS */
TXdata={0x86,0x04,0x0d}. /* TAP=16 */
TXdata={0x88,0x00,0x0d}. /* UART Manual mode */
TXdata={0x8C,0x06,0x0d}. /* GPIO=on,COUNT=on,CheckSum=off */
TXdata={0x8D,0xF0,0x0d}. /* FLAG=on,TEMP=on,Gyro=on,ACCL=on */
TXdata={0x8F,0x00,0x0d}. /* TEMP=16bit,Gyro=16bit,ACCL=16bit */
TXdata={0xFE,0x00,0x0d}. /* WINDOW=0 */
TXdata={0x83,0x01,0x0d}. /* move to Sampling mode */
```

receive sampling data.

(a)Wait until Data Ready signal is asserted.

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

(c)RXdata={0x80, FLAG\_Hi, FLAG\_Lo,  
TEMP\_HIGH\_Hi, TEMP\_HIGH\_Lo,  
XGYRO\_HIGH\_Hi, XGYRO\_HIGH\_Lo,  
YGYRO\_HIGH\_Hi, YGYRO\_HIGH\_Lo,  
ZGYRO\_HIGH\_Hi, ZGYRO\_HIGH\_Lo,  
XACCL\_HIGH\_Hi, XACCL\_HIGH\_Lo,  
YACCL\_HIGH\_Hi, YACCL\_HIGH\_Lo,  
ZACCL\_HIGH\_Hi, ZACCL\_HIGH\_Lo,  
GPIO\_Hi, GPIO\_Lo, COUNT\_Hi, COUNT\_Lo, 0x0d}

repeat from (a) to (c).

TXdata={0x83,0x02,0x0d}. /\* return to Configuration mode \*/

notes

Please remember to wait until Data Ready signal is asserted.

[Notes]

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

Please note that write data unit is 8bit.

XGYRO\_HIGH\_Hi: means MSByte of XGYRO\_HIGH data

XGYRO\_HIGH\_Lo: means LSByte of XGYRO\_LOW data

#### 8.2.4 Selftest (UART)

Selftest is as follows.

Power-on sequence. Please refer to Chapter 8.2.1.

(a) Send self test command.

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

/\* WINDOW=1 \*/

TXdata={0x83,0x04,0x0d}.

/\* Selftest command \*/

(b) Wait until selftest has finished.

Wait until SELF\_TEST bit goes to 0. SELF\_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 SELF\_TEST bit.

When SELF\_TEST becomes 0, it ends. Otherwise, please repeat (b).

(c) Confirm the result.

Confirm ST\_ERR bits. ST\_ERR is DIAG\_STAT[0x04(W0)]'s bit[14:11].

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

/\* WINDOW=0 \*/

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

/\* DIAG\_STAT read command \*/

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

/\* get response \*/

Confirm each ST\_ERR is 0.

If each ST\_ERR is 0, the result is OK. Otherwise, the result is NG.

#### 8.2.5 Software Reset (UART)

Software reset is as follows.

Power-on sequence. Please refer to Chapter 8.2.1.

(a) Send software reset command.

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

/\* WINDOW=1 \*/

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

/\* Software reset command \*/

(b) Wait 800ms.

#### 8.2.6 Flash Test (UART)

Flash test is as follows.

Power-on sequence. Please refer to Chapter 8.2.1.

(a) Send flash test command.

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

/\* WINDOW=1 \*/

TXdata={0x83,0x08,0x0d}.

/\* Flash test command \*/

(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=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.

### 8.2.7 Flash Backup (UART)

Flash backup is as follows.

Power-on sequence. Please refer to Chapter 8.2.1.

(a) Send flash backup command.

TXdata={0xFE,0x01,0x0d}. /\* WINDOW=1 \*/  
 TXdata={0x8A,0x08,0x0d}. /\* Flash backup command \*/

(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=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.

### 8.2.8 Filter setting (UART)

Filter setting is as follows.

Power-on sequence. Please refer to Chapter 8.2.1.

(a) Send filter setting command for moving average filter and TAP32.

TXdata={0xFE,0x01,0x0d}. /\* WINDOW=1 \*/  
 TXdata={0x86,0x05,0x0d}. /\* Filter setting command \*/

(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).

### 8.2.9 Auto Start (UART only)

Auto Start is as follows.

Power-on sequence. Please refer to Chapter 8.2.1.

(a) Set registers.

```
TXdata={0xFE,0x01,0x0d}.      /* WINDOW=1 */
TXdata={0x85,0x04,0x0d}.      /* 125SPS */
TXdata={0x86,0x04,0x0d}.      /* TAP=16 */
TXdata={0x88,0x03,0x0d}.      /* UART Auto mode, Auto start=on */
TXdata={0x8C,0x06,0x0d}.      /* GPIO=on,COUNT=on,CheckSum=off */
TXdata={0x8D,0xF0,0x0d}.      /* FLAG=on,TEMP=on,Gyro=on,ACCL=on */
TXdata={0x8F,0x70,0x0d}.      /* TEMP=32bit,Gyro=32bit,ACCL=32bit */
```

(b) Execute Flash backup. Please refer to Chapter 8.2.7.

(c) Power-off.

(d) power-on.

(e) Wait 800ms.

(f) receive sampling data.

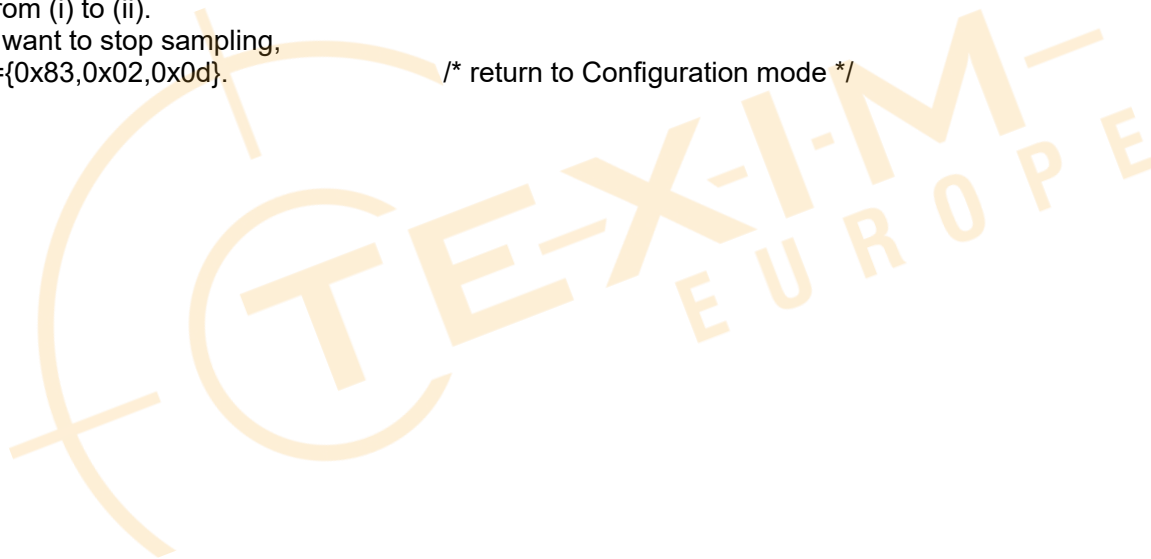
(i) Wait until Data Ready signal is asserted.

```
(ii) RXdata={0x80, FLAG_Hi, FLAG_Lo,
TEMP_HIGH_Hi, TEMP_HIGH_Lo, TEMP_LOW_Hi, TEMP_LOW_Lo,
XGYRO_HIGH_Hi, XGYRO_HIGH_Lo, XGYRO_LOW_Hi, XGYRO_LOW_Lo,
YGYRO_HIGH_Hi, YGYRO_HIGH_Lo, YGYRO_LOW_Hi, YGYRO_LOW_Lo,
ZGYRO_HIGH_Hi, ZGYRO_HIGH_Lo, ZGYRO_LOW_Hi, ZGYRO_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,
GPIO_Hi, GPIO_Lo, COUNT_Hi, COUNT_Lo, 0x0d}
```

repeat from (i) to (ii).

(g) If you want to stop sampling,

```
TXdata={0x83,0x02,0x0d}.      /* return to Configuration mode */
```



## 9. Handling Notes

### 9.1 Cautions for use

- When you attach the product to a housing, equipment, jig, or tool, make sure you attach it properly so that no mechanical stress is added to create a distortion such as a warp or twist. In addition, tighten the screws firmly but not too firmly because the mount of the product may break. Use screw locking techniques as necessary.
- When you set up the product, make sure the equipment, jigs, tools, and workers maintain a good ground in order not to generate high voltage leakage. If you add overcurrent or static electricity to the product, the product may be damaged permanently.
- When you install the product, make sure metallic or other conductors do not enter the product. Otherwise, malfunction or damage of the product may result.
- If excessive shock is added to the product when, for example, the product falls, the quality of the product may be degraded. Make sure the product does not fall when you handle it.
- Before you start using the product, test it in the actual equipment under the actual operating environment.
- Since the product has capacitors inside, inrush current will occur during power-on. Evaluate in the actual environment in order to check the effect of the supply voltage drop by inrush current in the system.
- If water enters the product, malfunction or damage of the product may result. If the product can be exposed to water, the system must have a waterproof structure. We do not guarantee the operation of the product when the product is exposed to condensation, dust, oil, corrosive gas (salt, acid, alkaline, or the like), or direct sunlight.
- This product is not designed to be radiation resistant.
- Never use this product if the operating condition is over the absolute maximum rating. If you do, the characteristics of the product may never recover.
- If the product is exposed to excessive exogenous noise or the like, degradation of the precision, malfunction, or damage of 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.
- Mechanical vibration or shock, continuous mechanical stress, rapid temperature change, or the like may cause cracks or disconnections at the various connecting parts.
- Take sufficient safety measure for the equipment this product is built into.
- This product is not intended for general use by the consumer but instead for engineering design. For the customer, please consider it safely with the proper use.
- This product is not designed to be used in the 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.). Therefore, Seiko Epson Corporation will not be liable for any damages caused by the use of the product for those applications.
- Do not alter or disassemble the product.
- The casing of this product is electrically conductive. When the product is connected or mounted to the circuit board, ensure the board substrate or board wiring pattern does not short-circuit or contact to the case.

### 9.2 Cautions for storage

- Do not add shock or vibration to the packing box. Do not spill water over the packing box. Do not store or use the product in the environment where dew condensation occurs due to rapid temperature change.
- To suppress the characteristic change by prolonged storage, it is recommended to maintain the environment at normal temperature and normal humidity. Normal temperature: +5 ~ +35 °C  
Normal humidity: 45%RH ~ 85%DH (JIS Z 8703).
- Do not store the product in a location subject to High Temperature, high humidity, under direct sunlight, corrosive gas or dust.
- Do not put mechanical stress on the product while it is stored.

### 9.3 Other cautions

- When you connect the socket to the header of this product, make sure you do not insert the header in the reverse orientation. If you do, the IMU may be damaged permanently. In addition, if you attach the product to the equipment, etc. using connection harness, connect the connection harness to the product first, and then attach it to the equipment, etc.
- The gloss marks derived from the adhesive material may have appeared on the casing surface of the product, but it does not affect the function and quality of the product.
- The Parting line as a result of die cast manufacturing process may have appeared on the casing surface of the product, but it is not an abnormality.
- Please take care not to tamper with or accidentally disturb the assembly screw on the surface where the serial number is printed when attaching and detaching the product to the system. We do not guarantee the performance and the quality of the product in case the assembly screw is manipulated.
- Never turn off power while the host communicates the product. Otherwise, malfunction of the product may result.
- Small performance deterioration due to long-term use and aging effects, etc. cannot be detected through the self-test in this product. Discontinue use immediately even when the self-test results in a “pass” when experiencing abnormality in the sensor performance.
- If noise is induced on the external trigger terminal, there is a possibility an invalid measurement process is unintentionally sent to the host. To prevent this, when using an external trigger, take precaution to minimize noise on the external trigger terminal.  
Exercise care and precaution with the packaging and during transport of the equipment that this product is installed on to avoid excessive vibration and or damage from impact.

### 9.4 Limited warranty

- The product warranty period is one year from the date of shipment.  
If a defect due to a quality failure of the product is found during the warranty period, we will promptly provide a replacement.

## 10. Part Number / Ordering Info.

The following is the ordering code for the IMU:

- X2G000091000600 : M-G370PDS0

## 11. Evaluation Tools

Evaluation tools can be provided for the IMU. For details, contact our representatives.

- PCB BOARD
- USB I/F BOARD & Logger Software

**Revision History**

Attachment-1

Rev. No.	Date	Page	Category	Contents
Rev 20201130	2020/11/30	All	new	Newly established
Rev 20210628	20210628	3	modify	unit change of Gyro Characteristics ° /s → ° /h
		4,18,22,56,57,68	correction	correction of errors.
Rev 20211001	2021/10/1	3	update	Sensor specifications are finalized
		10,11,18,31,32,33,74,89	update	Update due to specificationfix Typical Performance Characteristics, Self Test Delta Angle/Delta Velocity Output, Range Over Function,RunTimeDIAG, SERIAL_NUM Register, Part Number / Ordering Info
		25,26,27,28	update	Update for Filter Characteristics
Rev 20220401	2022/4/1	89	modify	Product Number Chnage

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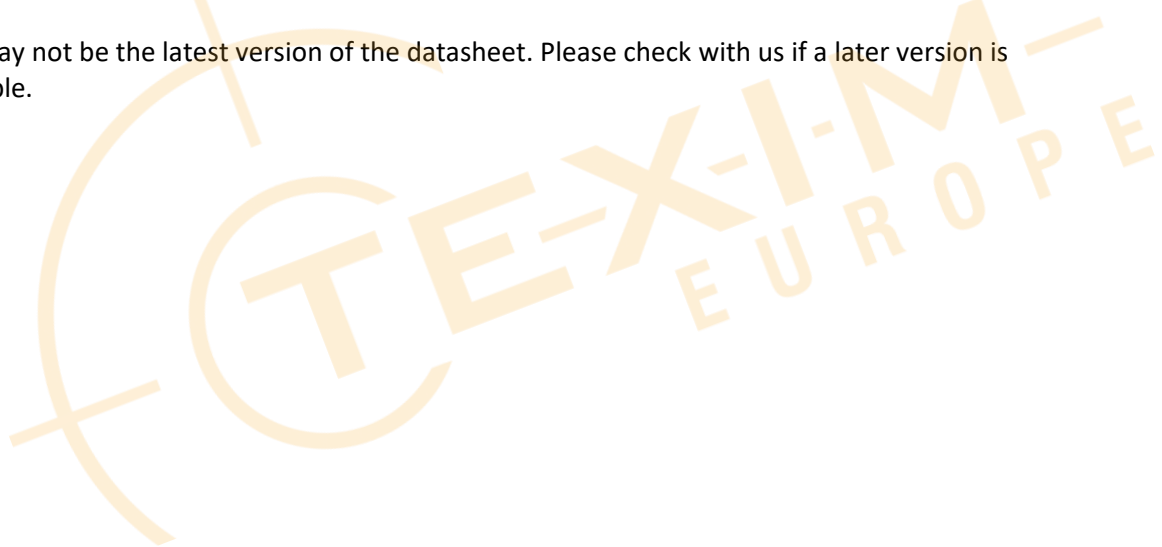
It is the customer's responsibility to validate that a particular product with the properties described in the product specification is suitable for use in a particular application.

Parameters provided in datasheets and / or specifications may vary in different applications and performance may vary over time.

All operating parameters, including typical parameters, must be validated for each customer application by the customer's technical experts.

Please contact us if you have any questions about the contents of the datasheet.

This may not be the latest version of the datasheet. Please check with us if a later version is available.





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