EPSON

IMU (Inertial Measurement Unit) – RS422 Interface

M-G552PR1x
Data Sheet

SEIKO EPSON CORPORATION

Rev.1.4

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1. OVERVIEW

The M-G552PR1x is a small form factor inertial measurement unit (IMU) with 6 degrees of freedom: tri-axial angular rates and linear accelerations, and provides high-stability and high-precision measurement capabilities with the use of high-precision compensation technology.

The M-G552PR1x features a built-in attitude angle output function using an extended Kalman filter optimized for high-speed operation and highly accurate attitude angle (Roll/Pitch). This exceptional real time performance is achieved using our unique DSP processing architecture for efficiency, and low power consumption. The application or system level power consumption and complexity can be reduced by offloading the high-speed processing from the host system that would otherwise be necessary to achieve highly dynamic posture angle.

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 RS422 interface support for host communication, the M-G552PR1x reduces technical barriers for users to introduce inertial measurement and minimizes design resources to implement inertial movement analysis and control applications.

This unit is packaged in a waterproof and dustproof metallic case. It is suitable for use in industrial and heavy duty 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

Item		Specification	Note
Sensor			
	Integrated Sensor	SEIKO EPSON inertial measurement sensor Low-Noise, High-stability Gyro Bias Instability: 1.2 °/h Angular Random Walk : 0.08 °/√h Initial Bias Error : 360 °/h (1σ) / 4 mG(1σ) 6 Degree Of Freedom Triple Gyroscope : ±450 °/s Tri-Axis Accelerometer : ±10 G Tilt Function Inclination mode : ±80 ° Euler mode: ±180 °(Pitch), ±45 °(Roll) Resolution: 0.01 ° , Static :±0.2 ° (1σ), Dynamic :±0.2 ° (1σ) 16bit / 32bit Data Resolution Calibrated Stability (Bias, Scale Factor, Axial Alignment)	
Interface			
	Protocol (DL layer)	RS-422 (TX/RX Pair, Full-Duplex transmission)	
	Bit Rate	460.8k bps /230.4k bps / 921.6k bps	460.8k bps (default)
	Cable Length	250m (max)	
	Terminator	Included (120Ωtyp)	
General Specification			
	Voltage supply	9 V~ 32V	
	Power consumption	42 mA typ. (Vin=12V)	

	Item	Specification	Note
	Operating temperature range	-30 °C ~ +80 °C	
External Dimension			
	Outer Packaging	Overall metallic shield case	
	Size	65 x 60 x 30 mm^3 (Not including projection.)	
	Weight	115 g (Subject to change)	
	Interface Connector	M12 connector: 8-pos (male), waterproof	
	WaterProof , DustProof:	IP67 equivalent	
External Dimension　(Applicable only for Mass production)			
	EU	CE marking (EN61326、RoHS Directive)	Class A
	FCC	FCCpart15B	Class A

1.2. Block Diagram

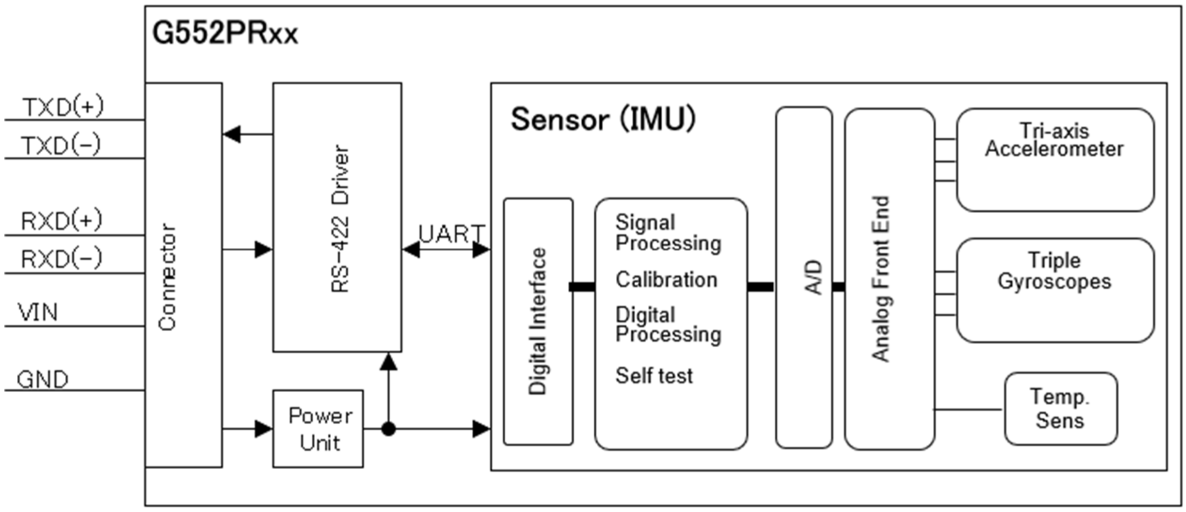


Figure 1-1 Functional Block Diagram

2. SPECIFICATIONS

2.1. Absolute Maximum Ratings

Table 2-1 Absolute Maximum Rating

Parameter	Term	Conditions	Range	Unit
Power Supply Voltage	V_{IN}	V+ to GND	-0.3 ~ +32V	V
Port Input Voltage	V_{port}	SIGNAL to GND	-3 ~ +32	V
Storage Temperature	T_{STG}		-40 ~ +85	°C
Operating Temperature1	T_{OPR1}		-30～+80	°C
Random vibration	—	1 hour MIL-STD-810, METHOD 514.x ANNEX E, Category24	7.7	Grms
Sine sweep vibration	—	4 hours / axis MIL-STD-202G, METHOD 204	10	G
Acceleration / Shock	—	Half-sine 0.5msec once per ±each axis(6times)	1000	G

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

2.2. Recommended Operating Conditions

Table 2-2 Recommended Operating Conditions

Ta=25°C, Vin=12V, RL=60Ω, unless otherwise specified; all voltages are defined with respect to ground

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Power Supply Voltge	V_{IN}	V+ to GND (*1)	9	12 (24)	32	V
Port Input Voltage	V_{PORT}	SIGNAL to GND	-2	-	7	V
Operating Temperature	T_{OPE}		-30	-	80	°C

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

2.3. Electrical Characteristics

Table 2-3 Sensor Characteristics

T_A=25°C, angular rate=0 °/s, ≤±1G, unless otherwise noted.

Parameter	Test Conditions / Comments		Min.	Typ.	Max.	Unit
Gyroscope						
Sensitivity						
Output Range			—	±450	—	°/s
Scale Factor	16bit		-0.2%	66	+0.2%	LSB / (°/s)
	32bit		-0.2%	66x(2^16)	+0.2%	
Nonlinearity (Best fit straight line)	1 σ, <300 deg/s		—	0.05	—	% of FS
	1 σ, >300 deg/s		—	0.2	—	% of FS
Misalignment	1 σ,Axis-to-axis, Δ = 90° ideal		—	0.01	—	°
Bias						
Initial Error	1 σ, −30°C ≤ T_A ≤ +80°C		—	360	—	°/h
Repeatability	1 σ, turn-on to turn-on *3		—	36	—	°/h
Bias Instability	Average		—	1.2	—	°/h
Angular Random Walk	Average		—	0.08	—	°/√h
Linear Acceleration Effect	Average			18		(°/h)/G
Noise Density	f = 10 to 20 Hz		—	6.9	—	(°/h)/√Hz, rms
Frequency Property						
3 dB Bandwidth			—	472	—	Hz
Accelerometer						
Sensitivity						
Output Range	—		—	±10	—	G
Scale Factor	16bit		-0.1%	2.5	+0.1%	LSB /mG
	32bit		-0.1%	2.5 x(2^16)	+0.1%	
Nonlinearity (Best fit straight line)	1 σ, ≤ 5G		—	0.1	—	% of FS
Misalignment	1 σ,Axis-to-axis, Δ = 90° ideal		—	0.01	—	°
Bias						
Initial Error	1 σ, −30°C ≤ T_A ≤ +80°C		—	4	—	mG
Repeatability	1 σ, turn-on to turn-on *3		—	3	—	mG
Bias Instability	Average		—	16	—	μG
Velocity Random Walk	Average		—	0.033	—	(m/s)/√hr
Noise Density	f = 10 to 20 Hz		—	80	—	μG/√Hz, rms
Frequency Property						
3 dB Bandwidth			—	167	—	Hz
Attitude Output						
Dynamic Range	Inclination Mode		-80	—	+80	°
	Euler Mode	ANG1(roll)	-45	—	+45	°
		ANG2(pitch)	-180	—	+180	°
		ANG3(yaw) *4	-180	—	+180	°
Scale Factor	16bit		—	0.00012207	—	rad/LSB
			—	0.00699411	—	°/LSB
Accuracy*4*6	1σ, Static		—	0.2	—	°
	1σ, Dynamic *5 (100 °/s, max)		—	0.2	—	°
Temperature Sensor						
Scale Factor *1*2	16bit Output=2634(0x0A4A)@+25°C		—	-0.0037918	—	°C/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.

*4) Yaw axis is not compensated for errors caused by drift.

*5) Dynamic accuracy is based on measurement data that has been measured from a stationary state.

*6) Attitude output accuracy is based on measurement data for modeA of motion profile.

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 1σ 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 Characteristic

Ta=25°C, Vin=12V, unless otherwise specified; all voltages are defined with respect to ground; positive currents flow into the sensor unit.

Parameter	Test Conditions	Min	Typ.	Max	Unit
Driver					
Differential Output Voltage	RL=120Ω,TD- to TD+	2	2.5		V
	RL=54Ω, TD- to TD+	1.5	2		V
Common Mode Output Voltage	RL=120Ω	1	2.5	3	V
Output Resistance			120		Ω
Rise or Fall Time	RL=120Ω			400	ns
Receiver					
Differential Input voltage		-25		25	V
Input Resistance			120		Ω
FUNCTIONAL TIMES (Time until data is available)					
Power-On Start-Up Time	-	-	-	800	ms
Reset Recovery Time	-	-	-	800	ms
Flash Test Time	-	-	-	5	ms
Flash Backup Time	-	-	-	200	ms
Self Test Time	-	-	-	80	ms
Filter Setting Time		-	-	1	ms
DATA OUTPUT RATE	DOUT_RATE = 0x00	-	-	2000	Sps
Clock Accuracy				±0.001	%

Table 2-5 Current Consumption

Ta=25°C, RL=60Ω, unless otherwise specified; all voltages are defined with respect to ground; positive currents flow into the sensor unit; Sampling mode; Sensor sample rate 1000Sps

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Mean Current in Measurement State	$I_{IN(SYNC)}$	Vin=12V	-	42	-	mA
		Vin=24V	-	23	-	mA
Mean Current in Idle State	$I_{IN(ready)}$	Vin=12V	-	38	-	mA
		Vin=24V	-	21	-	mA
Maximum Input Current	$I_{IN(max)}$		-	-	60.0	mA

2.4. Connector Specification

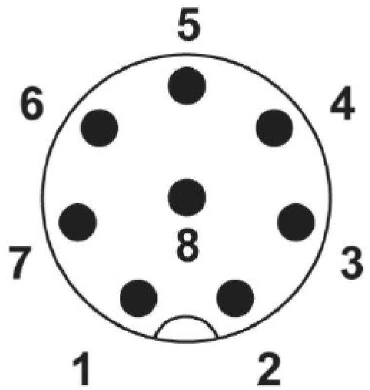


Figure 2-1 Terminal Layout

Table 2-6 Terminal Function

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

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

Note: Please use an M12-8 pin mating female connector that corresponds to IP67 specifications.
Table 2-7 Connector Part Number describes the connector manufacturer and the model number which is used in this product.

Table 2-7 Connector Part Number

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

2.5. Mechanical Dimensions

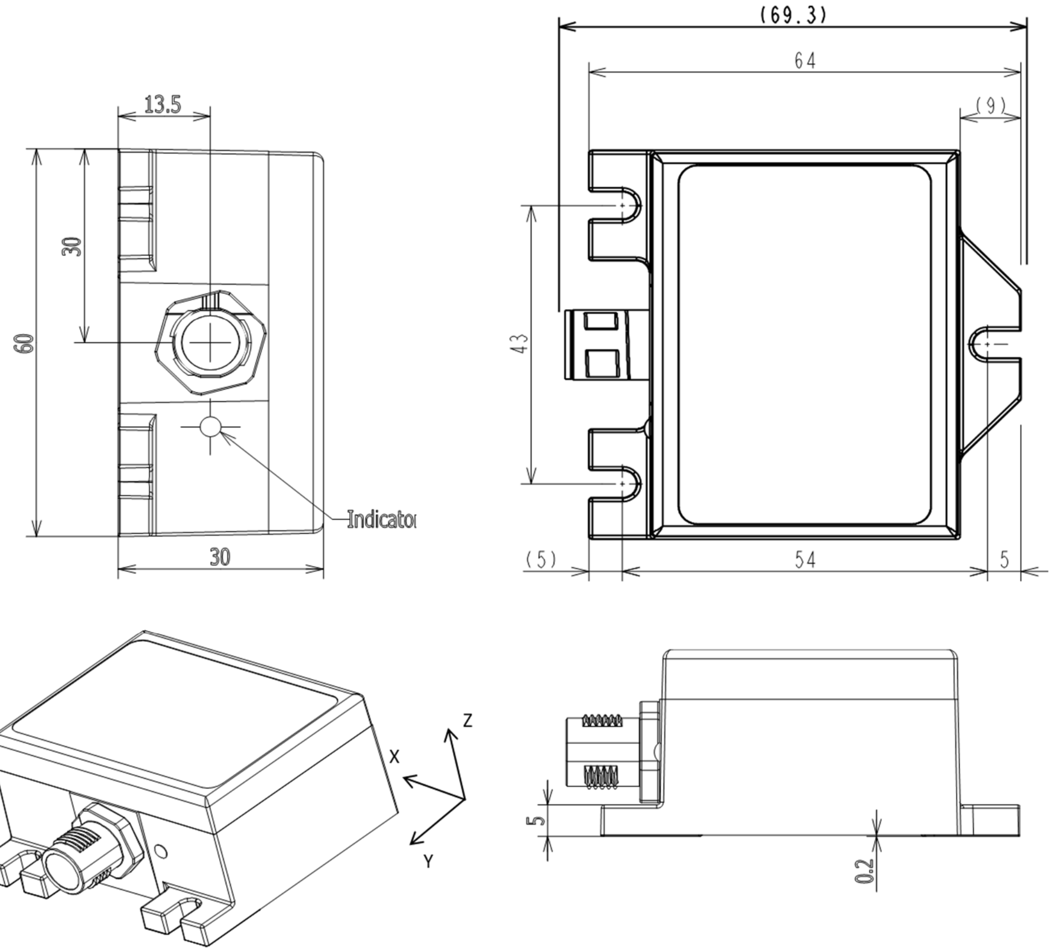


Figure 2-2 Outline Dimensions (millimeters)

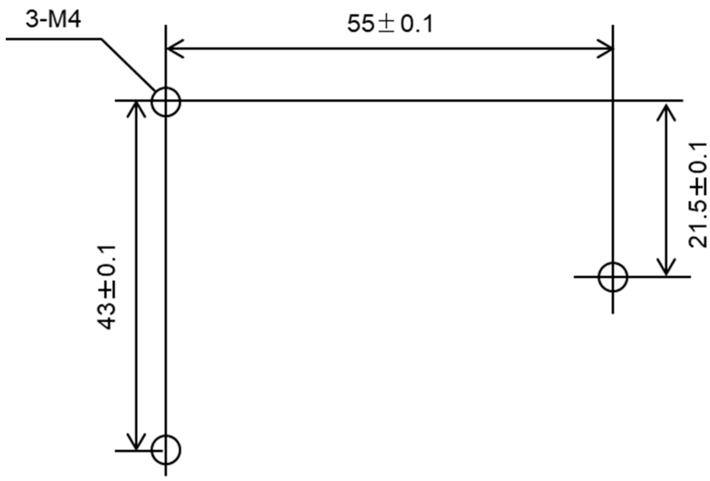


Figure 2-3 Recommended mounting dimensions (millimeters)

3. CONNECTION EXAMPLE

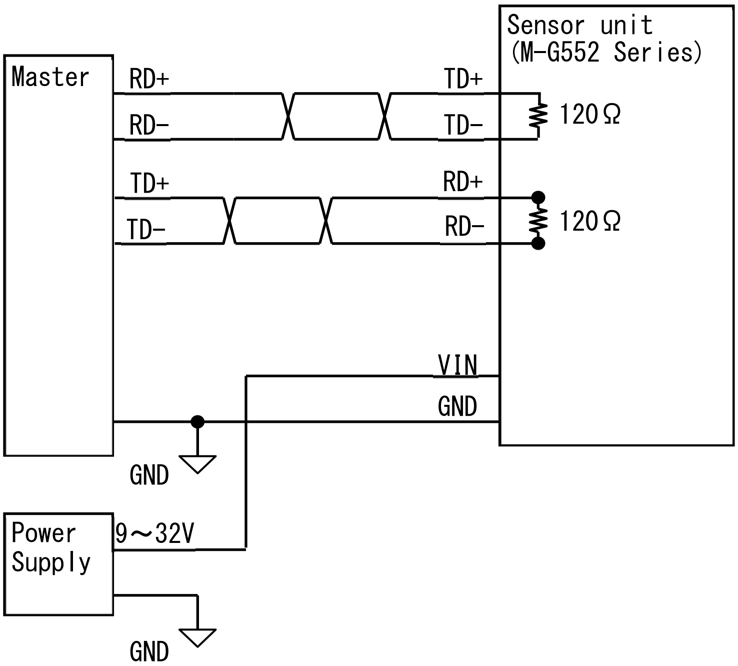


Figure 3-1 Connection Example

3.1. Precaution For Wiring And Cabling

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

3.2. Precaution For Supplying Power

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

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

Figure 3-2 Surge Protection Circuit describes the external reference protection circuit against lightning surge with a surge level based on IEC61000-4-5, +/-1kV(power supply line to the power supply ground) and +/-2kV(power supply line to the earth).

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

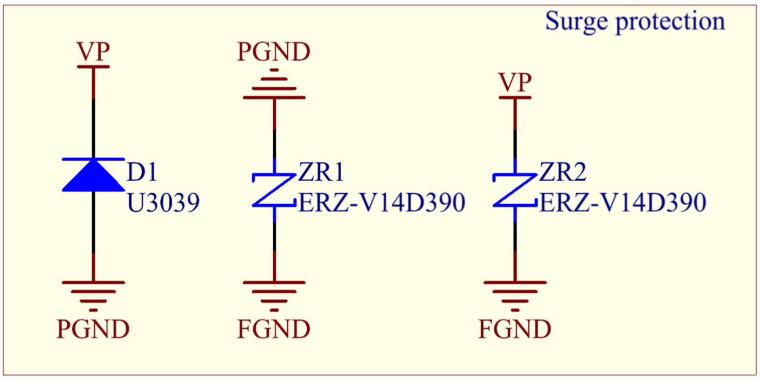


Figure 3-2 Surge Protection Circuit

4. TYPICAL PERFORMANCE CHARACTERISTICS

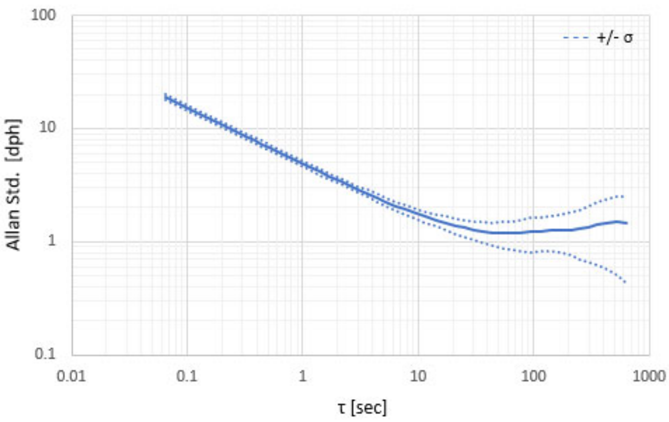


Figure 4-1 Gyro Allan Variance Characteristic

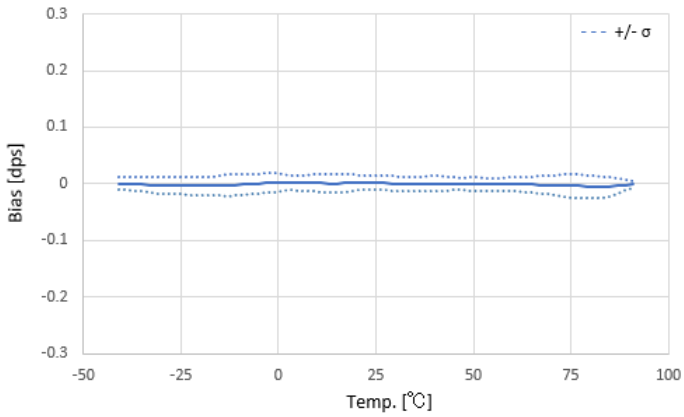


Figure 4-2 Gyro Bias vs. Temperature Characteristic

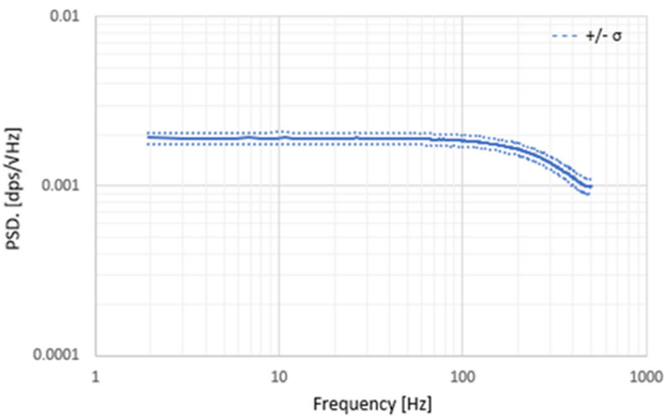


Figure 4-3 Gyro Noise Frequency Characteristic

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

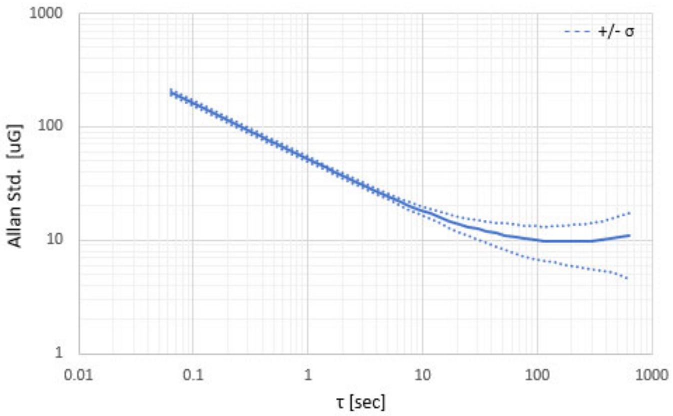


Figure 4-4 Accelerometer Allan Variance Characteristic

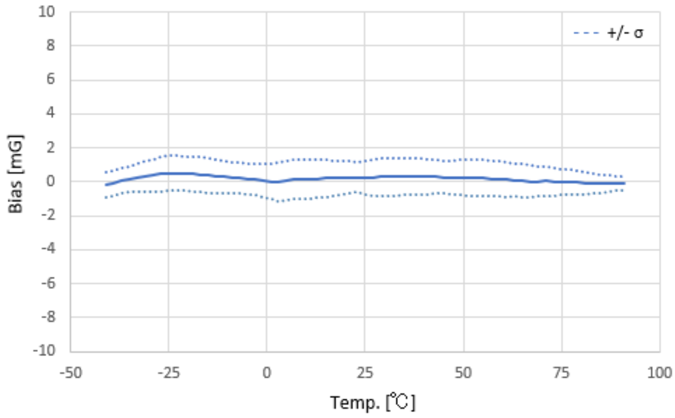


Figure 4-5 Accelerometer Bias vs. Temperature Characteristic

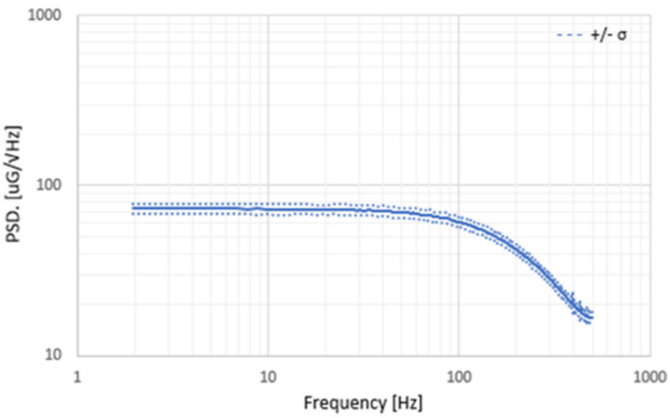


Figure 4-6 Accelerometer Noise Frequency Characteristic

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

5. BASIC OPERATION

5.1. Operation Mode

The device has the following two operation modes. Sampling mode has two submodes: Manual mode and Auto mode.

(1) Configuration mode
(2) Sampling mode
- Manual mode
- Auto mode

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(*1). 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.

Writing to **UART_AUTO** (UART_CTRL[0x08(W1)] bit[0]) can switch between the Manual mode and the Auto mode(*2).

*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 **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.

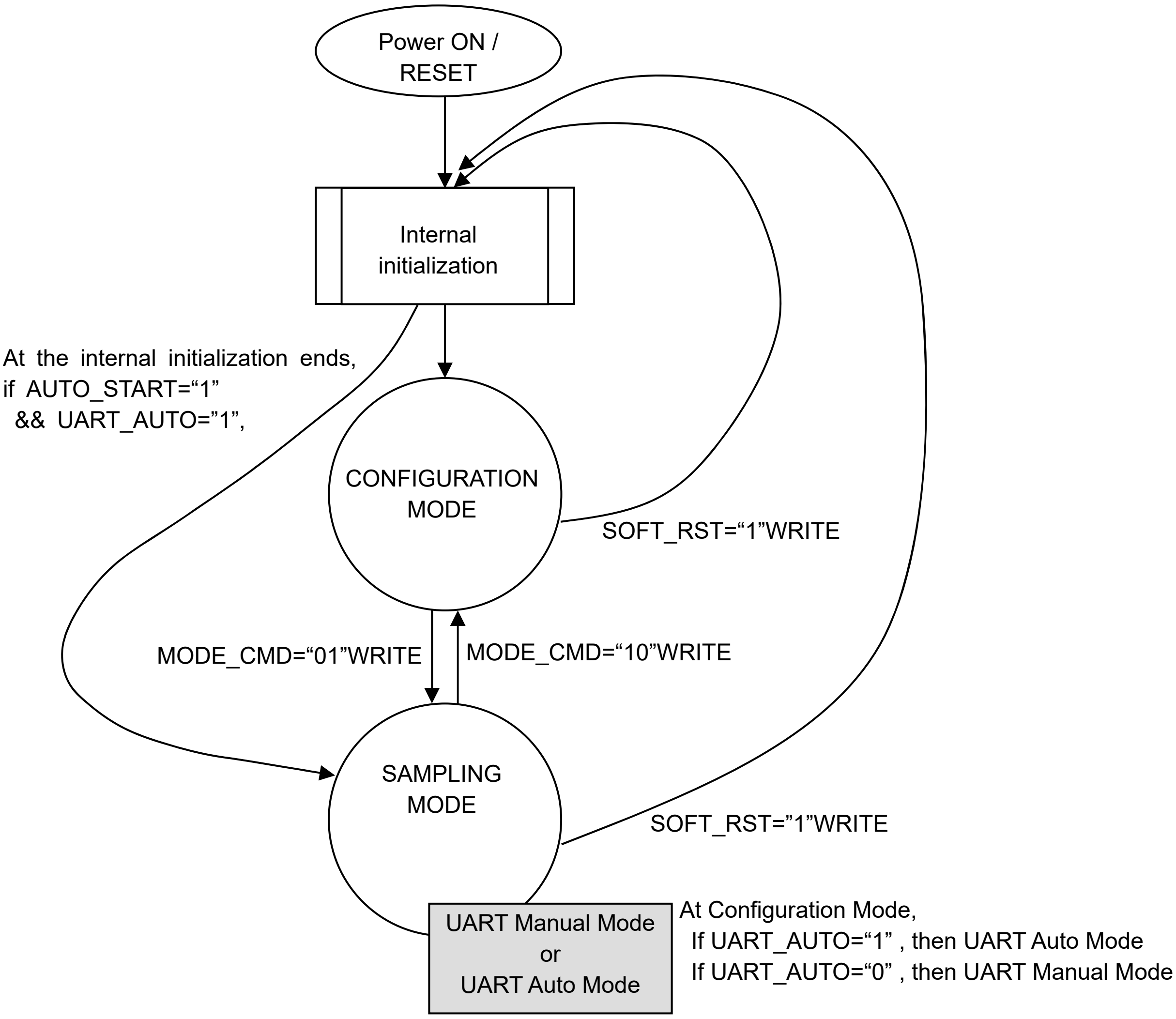


Figure 5-1 Operational State Diagram

5.2. Functional Block Diagram

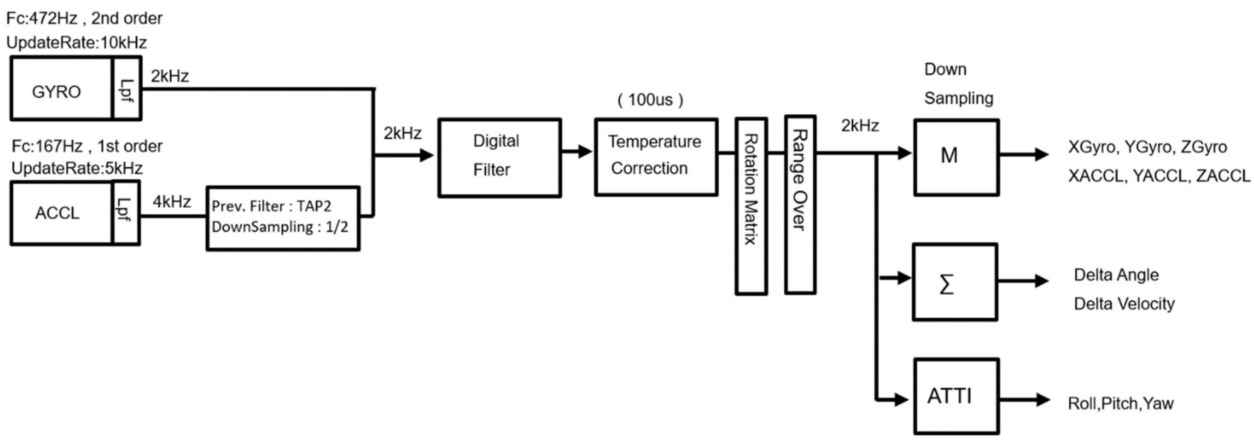


Figure 5-2 Functional Block Diagram

5.3. Sampling Counter

By reading COUNT[0x0A(W0)] register, the counter value can be read which is incremented based on the sampling completion timing of the internal A/D converter. The count interval is 500usec/count and is based on the precision of the internal reference oscillator (crystal).

Additionally, during UART burst mode and in UART Auto mode, the counter value can be included in the burst response by setting the **COUNT_OUT** (BURST_CTRL1[0x0C(W1)] bit[1]). For information about the response format, see 6.3 DATA PACKET FORMAT.

5.4. 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 Characteristic.

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]).

5.5. Checksum

A checksum can be appended to the response data during UART 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`"

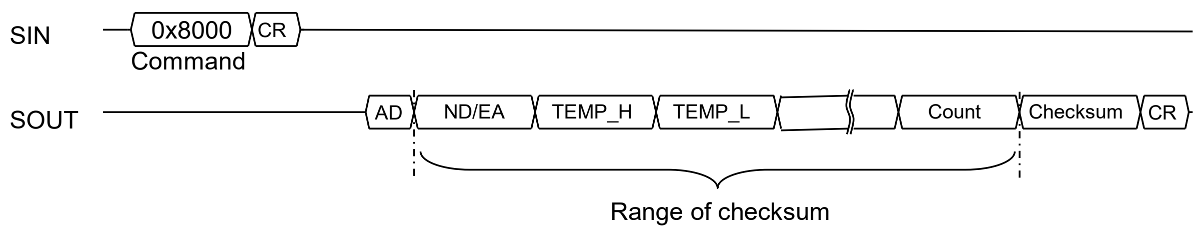


Figure 5-3 Checksum

5.6. 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 5-1 Operational State Diagram 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.

5.7. 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.

(1) Moving Average Filter:
TAP setting can be N= 2, 4, 8, 16, 32, 64, or 128.
Figure 5-4 shows the characteristics of this filter.

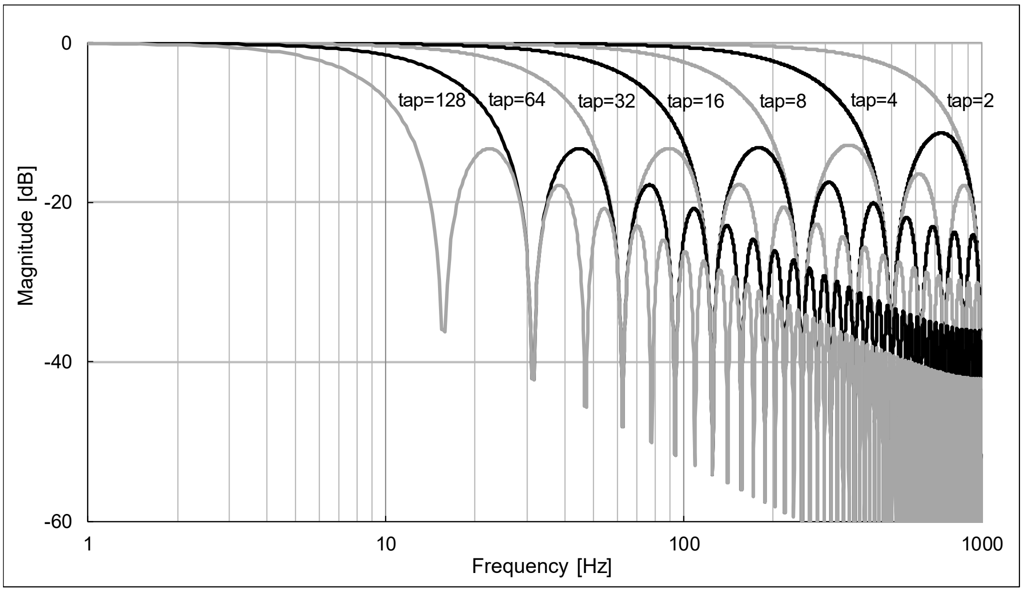


Figure 5-4 Moving Average Filter Characteristics

(2) FIR Kaiser filter:
Uses Kaiser Window(parameter=8)
TAP setting can be N= 32, 64, or 128 with cutoff frequency fc= 50, 100, 200, or 400Hz.
Figure 5-5 and Figure 5-6 show the typical characteristic of this filter.

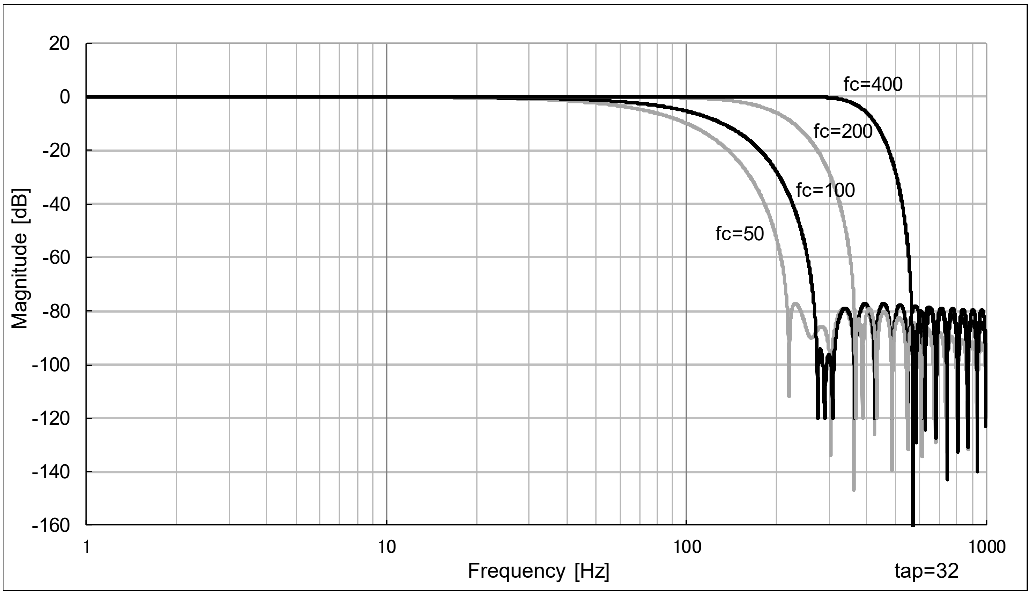


Figure 5-5 FIR Kaiser Filter Typical Characteristic 1

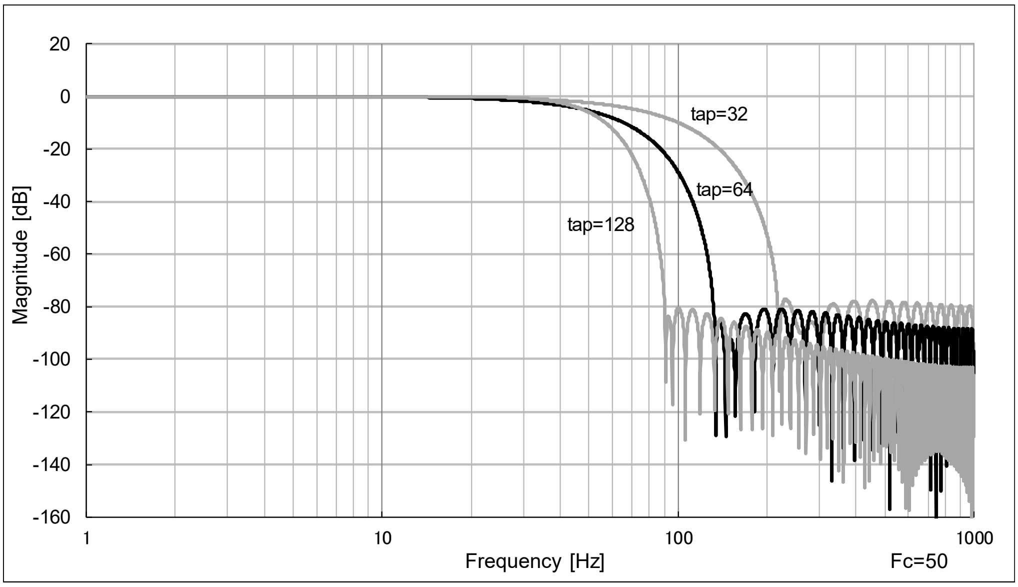


Figure 5-6 FIR Kaiser Filter Typical Characteristic 2

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 5-1 which describes the transient response in terms of number of samples for the combinations of output data rate and filter tap setting.

Table 5-1 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
500sps			0	1	3	7	15	31
400sps				1	3	6	12	25
250sps				0	1	3	7	15
200sps					1	3	6	12
125sps					0	1	3	7
100sps						1	3	6
80sps						1	2	5
62.5sps						0	1	3
50sps							1	3
40sps							1	2
31.25sps							0	1
25sps								1
20sps								1
15.625sps								0

5.8. 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)] = 0x02), 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 5-7 shows the timing diagram in the case of down-sampling ratio 4:1, 500sps and FilterTAP: N=4.

- Point A: By reading XDLTA_HIGH、XDLTA_LOW by Host at point A' (2ms 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.

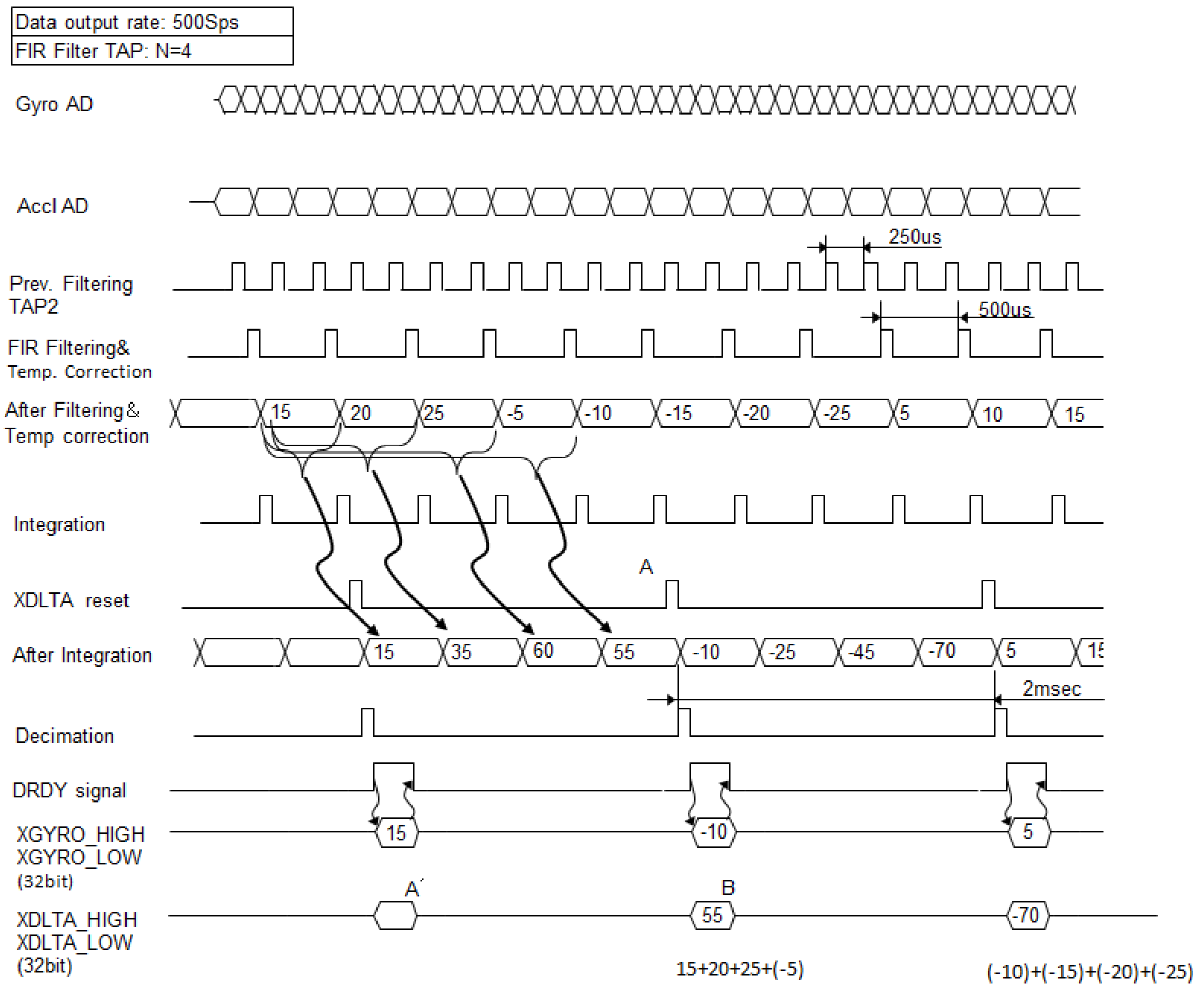


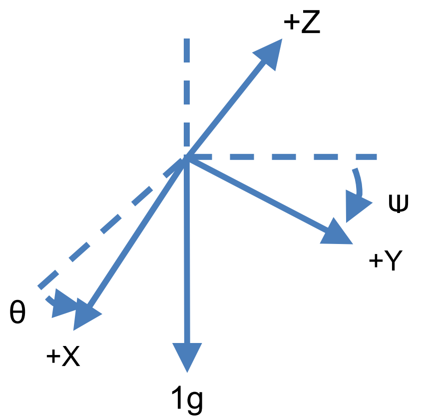
Figure 5-7 Delta Angle/Delta Velocity

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.

5.9. Attitude Output

This device supports Inclination mode or Euler angle mode as an attitude output function. This function can be set in ATTI_MODE bit 11 of ATTI_CTRL(0x14(W1). The definition of each mode is as follows.

- Inclination Mode



The inclination angle is the minimum angle that each axis rotates relative to the horizontal plane.

θ:ANG1 ATTI_ROLL(REG[0x64～0x67 (W0)]) Attitude angle data1 (x-axis relative to horizontal※1)

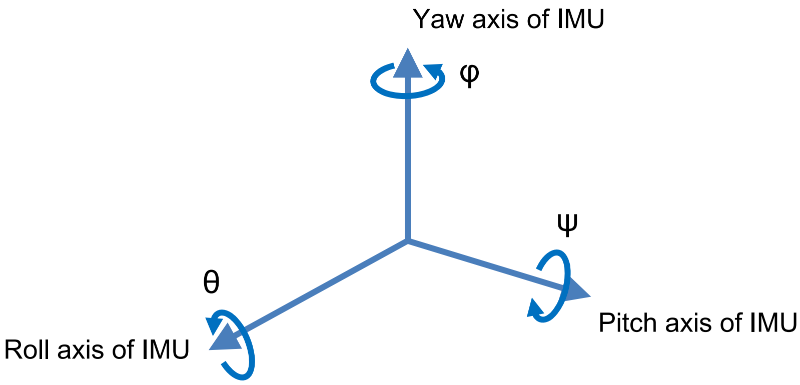
Ψ:ANG2 ATTI _PITCH (REG[0x68～0x6B (W0)]) Attitude angle data2 (y-axis relative to horizonta※1l)

※1) When ATTI_CONV bits of ATTI_CTRL [0x14 (W1)] bit [4:0] = "00" (default setting).

The designation of the ANG1 and ANG2 axes are programmable in ATTI_CONV bits of ATTI_CTRL[0x014(W1)] bits [4:0].

NOTE: For Inclination Mode, ANG3 ATTI_YAW (REG[0x6C～0x6F (W0)] Attitude angle data3 returns a fixed value of "0"

- Euler Angle Mode



The order of the rotation for Euler Angle Mode is ANG3(Yaw), ANG1(Roll), ANG2(Pitch) in a moving frame (each rotation is on the axes of a rotating coordinate system). The (+) rotation direction follows the "right hand" rule. The designation of the ANG1, ANG2, ANG3 axes are programmable in ATTI_CONV bits of ATTI_CTRL[0x014(W1)] bits [4:0].

θ:ANG1 ATTI_ROLL (REG[0x64～0x67 (W0)]) Attitude angle data1 (roll, x-axis rotation※1)

Ψ:ANG2 ATTI _PITCH (REG[0x68～0x6B (W0)]) Attitude angle data2 (pitch, y-axis rotation※1) φ：ANG3 ATTI _YAW (REG[0x6C～0x6F (W0)]) Attitude angle data3 (yaw, z-axis rotation※1)

※1) When ATTI_CONV bits of ATTI_CTRL [0x14 (W1)], bit [4: 0] = “00” (default setting).

To enable Attitude output, program the settings as shown below.

1. Enable burst data output by writing "1" to ATTI_OUT of BURST_CTRL1 [0x0D (W1)] bit8
2. Set the required bit length in ATTI_BIT of BURST_CTRL2 [0x0F (W1)] bit8.
3. Set the required attitude output mode in ATTI_MODE of ATTI_CTRL [0x15 (W1)] bit11.
4. Set the required attitude output axis conversion in ATTI_CONV of ATTI_CTRL [0x14 (W1)] bits [4:0].
5. Set ATTITUDE_MOTION_PROFILE of GLOB_CMD2 [0x16(W1)] bit[5:4].
6. Write "10" to ATTI_ON of ATTI_CTRL [0x15 (W1)] bits [10:9] to enable the attitude output function. Section 6.3 provides an example of the ANG1, ANG2, ANG3 output data fields for burst output in data packet format.

5.10. Quaternion Output

This device supports attitude output represented in quaternion format. The quaternion format is a 32-bit fixed point with the upper 2 bits (signed) integer part and the lower 30 bits fractional part.

q0： REG[0x50～0x53 (W0)]

q1： REG[0x54～0x57 (W0)]

q2： REG[0x58～0x5B (W0)]

q2： REG[0x5C～0x5F (W0)]

Each element of the quaternion is expressed as follows using the rotation axis unit vector "u" and the rotation angle "θ".

$$q_0 = \cos\frac{\theta}{2}$$

$$q_1 = u_x \sin\frac{\theta}{2}$$

$$q_2 = u_y \sin\frac{\theta}{2}$$

$$q_3 = u_z \sin\frac{\theta}{2}$$

To enable quaternion output, program the settings as shown below.

1. Enable burst data output by writing "1" to QTN_OUT of BURST_CTRL1 [0x0D(W1)] bit9.
2. Set the required bit length in QTN_BIT of BURST_CTRL2[0x0F(W1)] bit9.
3. Set ATTITUDE_MOTION_PROFILE of GLOB_CMD2 [0x16(W1)] bit[5:4].
4. Write "10" to ATTI_ON of ATTI_CTRL [0x15 (W1)] bits [10:9] to enable the quaternion output function.

   Section 6.2 Data Packet Format provides an example of the quaternion output data fields for burst output in data packet format.

5.11. 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 Electrical Characteristics.

Dynamic Range
Gyro Sensor :±450[deg/s]
Accelerometer :±10[G]

Detection is performed by "RangeOver" block in the processing order as described in Figure 5-2 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.

5.12. 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*.

6. DIGITAL INTERFACE

This device uses physical layer RS422A with an internal digital communication using a UART interface. The registers inside the device are accessed via this UART interface through the physical RS422A link.

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:

- Adjust the baud rate of UART interface in **BAUD_RATE** (UART_CTRL [0x08(W1)] bit 8).

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:

<u>Baudrate: 921600 Baud, Data output rate: 2000sps</u>

- **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)] = 0xF002: FLAG, TEMP, angle rate, acceleration, and COUNT output
- BURST_CTRL2 [0x0E(W1)] = 0x7000: TEMP, angle rate, and acceleration output are 32-bit.

<u>Baudrate: 460800 Baud, Data output rate: 1000sps</u>

- **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)] = 0xF002: FLAG, TEMP, angle rate, acceleration, and COUNT output
- BURST_CTRL2 [0x0E(W1)] = 0x7000: TEMP, angle rate, and acceleration output are 32-bit.

(2) 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)] = 0xF002: FLAG, TEMP, angle rate, acceleration, and COUNT output
- BURST_CTRL2 [0x0E(W1)] = 0x0000: TEMP, angle rate, and acceleration output are 16-bit.

6.1. UART Interface

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

Table 6-1 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)

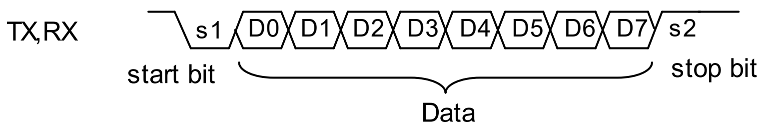


Figure 6-1 UART Bit Format

For the UART interface, a delimiter (1 byte) is placed at the end of each command (by the host) and response (by the IMU). In addition for responses, the address (1 byte) specified by the command is added (by the IMU) to the beginning of the response.
Table 6-2 and Table 6-3 shows the timing of UART.

Table 6-2 UART Timing

Parameter	Manual mode				Auto mode		Unit
	Normal mode		Burst mode				
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	
t_{STALL}(230.4kbps)	-	25	-	70	-	- *2	µs
t_{STALL}(460.8kbps)	-	25	-	70	-	- *2	µs
t_{STALL}(921.6kbps)	-	25	-	70	-	- *2	µs
$t_{WRITERATE}$(230.4kbps)	350	-	-	-	350	-	µs
$t_{WRITERATE}$(460.8kbps)	200	-	-	-	200	-	µs
$t_{WRITERATE}$(921.6kbps)	150	-	-	-	150	-	µs
$t_{READRATE}$(230.4kbps)	350	-	*1	-	- *2	-	µs
$t_{READRATE}$(460.8kbps)	200	-	*1	-	- *2	-	µs
$t_{READRATE}$(921.6kbps)	150	-	*1	-	- *2	-	µs

*1) Please refer to Table 6-3.

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

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

Parameter	Burst Mode (minimum)	Unit
$t_{READRATE}$(230.4kbps)	300 + (43.4 * B)	μs
$t_{READRATE}$(460.8kbps)	200 + (21.7 * B)	μs
$t_{READRATE}$(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(μs)

6.1.1. 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.

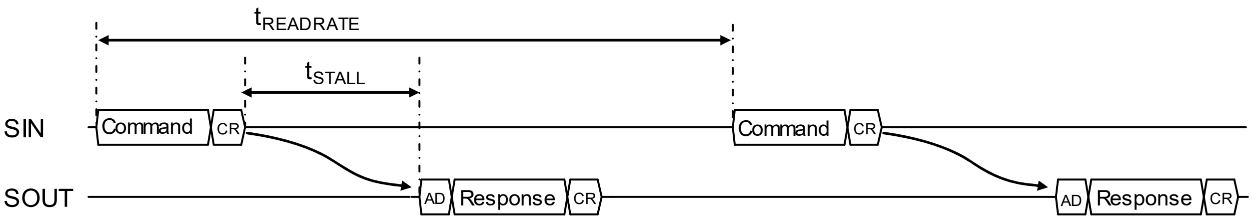


Figure 6-2 UART Read Timing (Normal Mode)

Table 6-4 Command Format (Read)

<table>
<tr><td colspan="8">First byte</td><td colspan="8">Second byte</td><td colspan="8">Third byte</td></tr>
<tr><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td colspan="7">A[6:0]</td><td colspan="8">XX</td><td colspan="8">0x0D</td></tr>
</table>

A[6:0] ･･･ Register address (even address)
XX ･･･ Don't Care
0x0D ･･･ Delimiter

Table 6-5 Response Format (Read)

<table>
<tr><td colspan="8">First byte</td><td colspan="8">Second byte</td><td colspan="8">Third byte</td><td colspan="8">Fourth byte</td></tr>
<tr><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td>0</td><td colspan="7">A[6:0]</td><td colspan="8">D[15:8]</td><td colspan="8">D[7:0]</td><td colspan="8">0x0D</td></tr>
</table>

A[6:0] ･･･ Register address (even address)
D[15:8] ･･･ Register read data (upper byte)
D[7:0] ･･･ Register read data (lower byte)
0x0D ･･･ Delimiter

6.1.2. 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, 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 6.2 Data Packet Format for the response format.

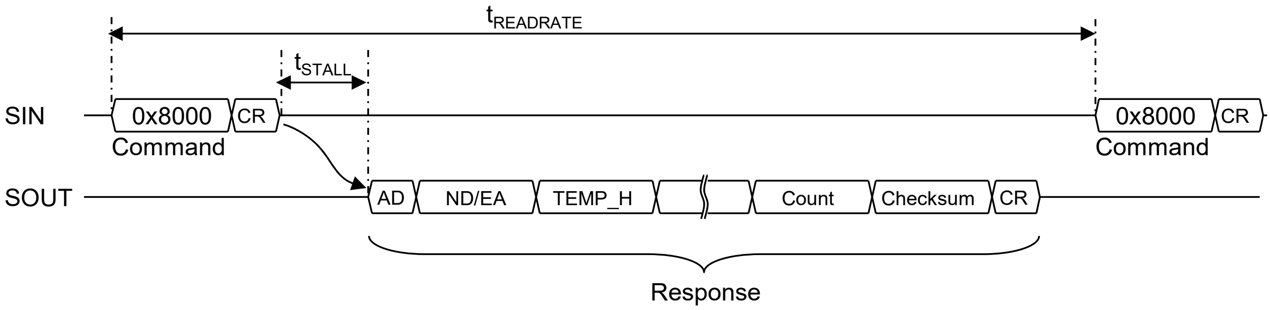


Figure 6-3 UART Read Timing (Burst Mode)

Table 6-6 Command Format (Burst Mode)

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

0x80 ··· Burst Command
0x00 ··· Burst Data 0x00
0x0D ··· Delimiter

6.1.3. UART Write Timing

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

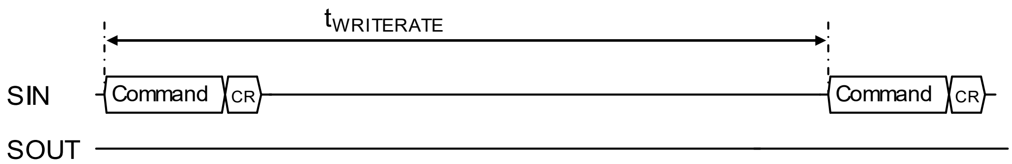


Figure 6-4 UART Write Timing

Table 6-7 Command Format (Write)

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

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

6.1.4. 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 6.2 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)].

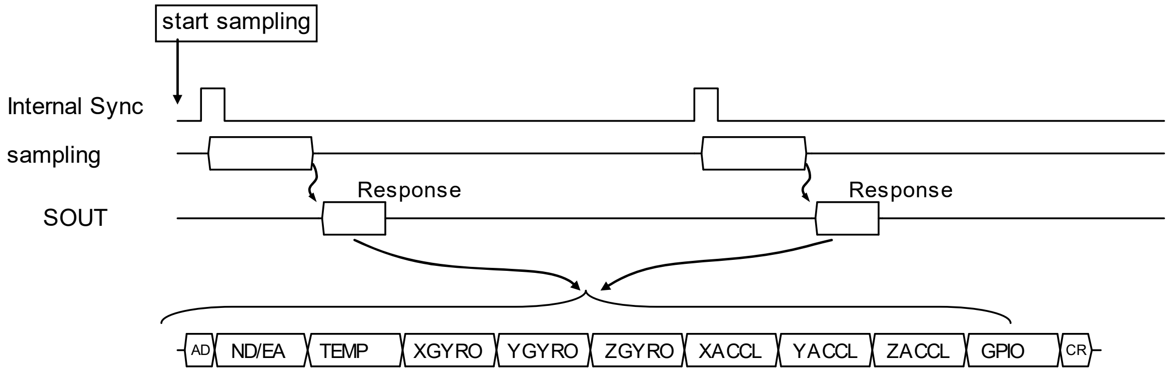


Figure 6-5 UART Auto Mode Operation

6.2. Data Packet Format

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

Table 6-8 UART Data Packet Format (UART Burst/Auto Mode) Example: 16-bit Output
BURST_CTRL1[0x0C(W1)]=0xF003 / 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)	-	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	COUNT_H	COUNT [15:8]							
19	COUNT_L	COUNT [7:0]							
20	CHECKSUM_H	CHECKSUM [15:8]							
21	CHECKSUM_L	CHECKSUM [7:0]							
22	CR	0x0D							

Table 6-9 UART Data Packet Format (UART Burst/Auto Mode) Example: 32-bit Output
BURST_CTRL1[0x0C(W1)]=0xF003 / 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)	-	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]							

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
32	COUNT_H	COUNT [15:8]							
33	COUNT_L	COUNT [7:0]							
34	CHECKSUM_H	CHECKSUM [15:8]							
35	CHECKSUM_L	CHECKSUM [7:0]							
36	CR	0x0D							

Table 6-10 DATA PACKET FORMAT (UART BURST/AUTO MODE) Example: 32-bit Output BURST_CTRL1[0x0C(W1)]=0xFC03 / 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)	-	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]							

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
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	COUNT_H	COUNT [15:8]							
57	COUNT_L	COUNT [7:0]							

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
58	CHECKSUM_H	CHECKSUM [15:8]							
59	CHECKSUM_L	CHECKSUM [7:0]							
60	CR	0x0D							

Table 6-11 UART Data Packet Format (UART Burst/Auto Mode) Example: 32-bit Output
BURST_CTRL1[0x0C(W1)]=0xF103 / BURST_CTRL2[0x0E(W1)]=0x7100

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)	-	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]							

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
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	ZACC_LOW_H	ZACCL_LOW [15:8]							
31	ZACCL_LOW_L	ZACCL_LOW [7:0]							
32	ANG1_HIGH_H	ANG1_HIGH [15:8]							
33	ANG1_HIGH_L	ANG1_HIGH [7:0]							
34	ANG1_LOW_H	ANG1_LOW [15:8]							
35	ANG1_LOW_L	ANG1_LOW [7:0]							
36	ANG2_HIGH_H	ANG2_HIGH [15:8]							
37	ANG2_HIGH_L	ANG2_HIGH [7:0]							
38	ANG2_LOW_H	ANG2_LOW [15:8]							
39	ANG2_LOW_L	ANG2_LOW [7:0]							
40	ANG3_HIGH_H	ANG3_HIGH [15:8]							
41	ANG3_HIGH_L	ANG3_HIGH [7:0]							
42	ANG3_LOW_H	ANG3_LOW [15:8]							
43	ANG3_LOW_L	ANG3_LOW [7:0]							
44	COUNT_H	COUNT [15:8]							
45	COUNT_L	COUNT [7:0]							
46	CHECKSUM_H	CHECKSUM [15:8]							
47	CHECKSUM_L	CHECKSUM [7:0]							
48	CR	0x0D							

Table 6-12 DATA PACKET FORMAT (UART BURST/AUTO MODE) Example: 32-bit Output
BURST_CTRL1[0x0C(W1)]=0xF203 / BURST_CTRL2[0x0E(W1)]=0x7200

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)	-	EA
4	TEMP_HIGH_H	TEMP_HIGH [15:8]							
5	TEMP_HIGH_L	TEMP_HIGH [7:0]							

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
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	QTN0_HIGH_H	QTN0_HIGH [15:8]							
33	QTN0_HIGH_L	QTN0_HIGH [7:0]							
34	QTN0_LOW_H	QTN0_LOW [15:8]							
35	QTN0_LOW_L	QTN0_LOW [7:0]							
36	QTN1_HIGH_H	QTN1_HIGH [15:8]							
37	QTN1_HIGH_L	QTN1_HIGH [7:0]							
38	QTN1_LOW_H	QTN1_LOW [15:8]							

Byte No.	Name	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
39	QTN1_LOW_L	QTN1_LOW [7:0]							
40	QTN2_HIGH_H	QTN2_HIGH [15:8]							
41	QTN2_HIGH_L	QTN2_HIGH [7:0]							
42	QTN2_LOW_H	QTN2_LOW [15:8]							
43	QTN2_LOW_L	QTN2_LOW[7:0]							
44	QTN3_HIGH_H	QTN3_HIGH [15:8]							
45	QTN3_HIGH_L	QTN3_HIGH [7:0]							
46	QTN3_LOW_H	QTN3_LOW [15:8]							
47	QTN3_LOW_L	QTN3_LOW [7:0]							
48	COUNT_H	COUNT [15:8]							
49	COUNT_L	COUNT [7:0]							
50	CHECKSUM_H	CHECKSUM [15:8]							
51	CHECKSUM_L	CHECKSUM [7:0]							
52	CR	0x0D							

7. USER REGISTERS

A host device 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 Characteristic, 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**
- 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 7.32 describes the registers in detail.

The “-” sign in the register assignment table in Section 7.1 through Section 7.32 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
ID	0	0x4C	R		0x5345	ID read function
QTN0_HIGH	0	0x50	R		0x0000	Quaternion q0 High
QTN0_LOW	0	0x52	R		0x0000	Quaternion q0 Low
QTN1_HIGH	0	0x54	R		0x0000	Quaternion q1 High
QTN1_LOW	0	0x56	R		0x0000	Quaternion q1 Low
QTN2_HIGH	0	0x58	R		0x0000	Quaternion q2 High
QTN2_LOW	0	0x5A	R		0x0000	Quaternion q2 Low
QTN3_HIGH	0	0x5C	R		0x0000	Quaternion q3 High
QTN3_LOW	0	0x5E	R		0x0000	Quaternion q3 Low
XDLTA_HIGH / ANG1_HIGH [*1]	0	0x64	R		0x0000	X delta angle value High / ANG1 attitude output High
XDLTA_LOW / ANG1_LOW [*1]	0	0x66	R		0x0000	X delta angle value Low / ANG1 attitude output Low
YDLTA_HIGH / ANG2_HIGH [*1]	0	0x68	R		0x0000	Y delta angle value High / ANG2 attitude output High
YDLTA_LOW / ANG2_LOW [*1]	0	0x6A	R		0x0000	Y delta angle value Low / ANG2 attitude output Low
ZDLTA_HIGH / ANG3_HIGH [*1]	0	0x6C	R		0x0000	Z delta angle value High / ANG3 attitude output High
ZDLTA_LOW / ANG3_LOW [*1]	0	0x6E	R		0x0000	Z delta angle value Low / ANG3 attitude output 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	○	0x0103	Sampling control

FILTER_CTRL	1	0x07,0x06	R/W	O	0x0001	Filter control
UART_CTRL	1	0x09,0x08	R/W	O	0x0000	UART control
GLOB_CMD	1	0x0B,0x0A	R/W	O	0x0000	System control
BURST_CTRL1	1	0x0D,0x0C	R/W	O	0xF006	Burst control 1
BURST_CTRL2	1	0x0F,0x0E	R/W	O	0x0000	Burst control 2
POL_CTRL	1	0x11,0x10	R/W	O	0x0000	Polarity control
DLT_CTRL	1	0x13,0x12	R/W	O	0x00CC	Delta control
ATTI_CTRL	1	0x15,0x14	R/W		0x0000	Attitude control
GLOB_CMD2	1	0x17,0x16	R/W		0x0000	System control2
R_MATRIX_G_M11 *2	1	0x39,0x38	R/W	O	0x4000	Gyro R_Matrix coefficient
R_MATRIX_G_M12 *2	1	0x3B,0x3A	R/W	O	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M13 *2	1	0x3D,0x3C	R/W	O	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M21 *2	1	0x3F,0x3E	R/W	O	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M22 *2	1	0x41,0x40	R/W	O	0x4000	Gyro R_Matrix coefficient
R_MATRIX_G_M23 *2	1	0x43,0x42	R/W	O	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M31 *2	1	0x45,0x44	R/W	O	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M32 *2	1	0x47,0x46	R/W	O	0x0000	Gyro R_Matrix coefficient
R_MATRIX_G_M33 *2	1	0x49,0x48	R/W	O	0x4000	Gyro R_Matrix coefficient
R_MATRIX_A_M11 *2	1	0x4B,0x4A	R/W	O	0x4000	Accel R_Matrix coefficient
R_MATRIX_A_M12 *2	1	0x4D,0x4C	R/W	O	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M13 *2	1	0x4F,0x4E	R/W	O	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M21 *2	1	0x51,0x50	R/W	O	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M22 *2	1	0x53,0x52	R/W	O	0x4000	Accel R_Matrix coefficient
R_MATRIX_A_M23 *2	1	0x55,0x54	R/W	O	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M31 *2	1	0x57,0x56	R/W	O	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M32 *2	1	0x59,0x58	R/W	O	0x0000	Accel R_Matrix coefficient
R_MATRIX_A_M33 *2	1	0x5B,0x5A	R/W	O	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 In ATTI_CTRL register, ATTI_ON setting determines if Delta Angle or Attitude is output.

*2 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 6.1.2 UART Read Timing (Burst Mode). Also refer to 6.2 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		-	UART _OVF	FLASH _ERR	ST_ERR _ALL	FLASH _BU_ER R	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 that a SET Error condition has occurred.
SET ERRor condition occurs when 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])
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[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 or **FLASH_R_BACKUP** of GLOB_CMD2[0x017(W1)] bit 8.
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)	-	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[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**
bit[1:0] **GPIO_DIR**

* Default setting only

7.6. COUNT Register (Window 0)

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

bit[15:0] **COUNT**

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

NOTE: The time unit of the sampling counter value represents 500 μs/count.
Example: If the data output rate equals 1000Sps, the counter value sequence is 0,2,4,6, ... , 0xFFFE, 0, 2, ...

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	-							RO (Attitude)	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.

bit[0] **RO(Range Over) Flag (Attitude)**
The attitude RO flag is set to “1” when the output value exceeds the sensing range. The flag is 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.

For 32-bit usage: T [°C]= (SF/65536) * (A -172621824) + 25
For 16-bit usage: T [°C]= SF * (A -2634) + 25

SF: Scale Factor
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 2-2 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 Characteristics for the Scale Factor value.

For 32-bit usage: G [deg/s]= ((1/SF)/65536) * B
For 16-bit usage: G [deg/s]= (1/SF) * B

SF: Scale Factor
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 2-2 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 Characteristics for the Scale Factor value.

For 32-bit usage: A [mG]= ((1/SF)/65536) * C
For 16-bit usage: A [mG]= (1/SF) * C

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

7.11. 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.

7.12. QUATERNION Register (Window 0)

Addr (Hex)	Bit15	. . .	Bit0	R/W
0x50	QTN0_HIGH			R
0x52	QTN0_LOW			R
0x54	QTN1_HIGH			R
0x56	QTN1_LOW			R
0x58	QTN2_HIGH			R
0x5A	QTN2_LOW			R
0x5C	QTN3_HIGH			R
0x5E	QTN3_LOW			R

bit[15:0] Quaternion
Returns the quaternion output format representing the attitude in a 32-bit fixed point format. The upper 2 bits (signed) are the integer part and the remaining 30 lower bits as the fractional part. For 16-bit usage, only the upper 16-bits are used.

Please refer to 5.10 Quaternion Output for a detailed description.

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 2-2 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: ⊿Angle [deg]= (SF/65536) * D
For 16-bit usage: ⊿Angle [deg]= 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 2-2 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: ⊿Velocity [m/s]= (SF/65536) * E
For 16-bit usage: ⊿Velocity [m/s]= SF * E

SF: Scale Factor **Refer to DLT_RANGE_CTRL setting*
E: Acceleration delta velocity output data (decimal)

7.15. ATTI Register (Window 0)

Addr (Hex)	Bit15	...	Bit0	R/W
0x64		ANG1_HIGH		R
0x66		ANG1_LOW		R
0x68		ANG2_HIGH		R
0x6A		ANG2_LOW		R
0x6C		ANG3_HIGH [*1]		R
0x6E		ANG3_LOW [*1]		R

bit[15:0] Attitude output data

Returns the attitude output data for ANG1, and ANG2 in inclination mode, or returns the attitude output data for ANG1, ANG2, and ANG3 in Euler angle mode.
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 Characteristics for the Scale Factor value for units in either radians or degrees.

For 32-bit usage: ATTI = (SF/65536) * D
For 16-bit usage: ATTI = SF * D

SF: Scale Factor
D: Attitude output data (decimal)

[*1] The ANG3 output, REG[0x6C~0x6F(W0)], is only valid in Euler angle mode and is fixed to 0 when in Inclination mode and should be ignored.

7.16. 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.

7.17. 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
00 : fixed value

bit[2] DRDY_ON
1 : fixed value

bit[1] DRDY_POL
1 : fixed value

NOTE:
FLASH_TEST and SELF_TEST cannot be executed at the same time. If you want to execute it continuously, wait for the bit that wrote 1 to return to 0 to confirm the end, and then execute the following command.

7.18. 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.

0x00 :2000Sps	TAP>=0
0x01 :1000Sps	TAP>=2
0x02 :500Sps	TAP>=4
0x03 :250Sps	TAP>=8
0x04 :125Sps	TAP>=16
0x05 :62.5Sps	TAP>=32
0x06 :31.25Sps	TAP>=64
0x07 :15.625Sps	TAP=128
0x08 :400 Sps	TAP>=8
0x09 :200 Sps	TAP>=16
0x0A :100 Sps	TAP>=32
0x0B :80 Sps	TAP>=32
0x0C :50 Sps	TAP>=64
0x0D :40 Sps	TAP>=64
0x0E :25 Sps	TAP=128
0x0F :20 Sps	TAP=128

NOTE: When attitude output is enabled (ATTI_ON[0x14(W1)] bit 10 = 1), the internal sampling rate is at 1000sps, and the data output rate must be set to 500sps or less.

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.
During a detected SET_ERR condition, the output registers TEMP_HIGH～TEMP_LOW / XGYRO_HIGH～ZGYRO_LOW / XACCL_HIGH～ZACCL_LOW / XDLTA_HIGH～XDLTA_LOW / XDLTV_HIGH ～ X_DLTV_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, 01

SMPL_CTRL[0x05(W1)]bit[11:8]	FILTER_CTRL[0x06(W1)]bit[4:0]																			
	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
1000	–	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	–
400	–	–	–	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	–	–
200	–	–	–	–	OK	OK	OK	OK	OK	OK	–	–	OK	OK	–	–	OK	OK	–	–
125	–	–	–	–	OK	OK	OK	OK	OK	–	–	–	OK	–	–	–	OK	–	–	–
100	–	–	–	–	–	OK	OK	OK	OK	–	–	–	OK	–	–	–	OK	–	–	–
80	–	–	–	–	–	OK	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
62.5	–	–	–	–	–	OK	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
50	–	–	–	–	–	–	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
40	–	–	–	–	–	–	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
31.25	–	–	–	–	–	–	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
25	–	–	–	–	–	–	–	OK	–	–	–	–	–	–	–	–	–	–	–	–
20	–	–	–	–	–	–	–	OK	–	–	–	–	–	–	–	–	–	–	–	–
15.625	–	–	–	–	–	–	–	OK	–	–	–	–	–	–	–	–	–	–	–	–

"OK"=Supported, "-"=Invalid

ATTI_CTRL[0x15(W1)]bit[10:9] ATTI_ON =10

SMPL_CTRL[0x05(W1)]bit[11:8]	FILTER_CTRL[0x06(W1)]bit[4:0]																			
	0	2	4	8	16	32	64	128	32Fc50	32Fc100	32Fc200	32Fc400	64Fc50	64Fc100	64Fc200	64Fc400	128Fc50	128Fc100	128Fc200	128Fc400
2000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
500	–	–	–	–	OK	OK	OK	OK	OK	OK	–	–	OK	OK	–	–	OK	OK	–	–
400	–	–	–	–	OK	OK	OK	OK	OK	OK	–	–	OK	OK	–	–	OK	OK	–	–
250	–	–	–	–	OK	OK	OK	OK	OK	OK	–	–	OK	OK	–	–	OK	OK	–	–
200	–	–	–	–	OK	OK	OK	OK	OK	OK	–	–	OK	OK	–	–	OK	OK	–	–
125	–	–	–	–	OK	OK	OK	OK	OK	–	–	–	OK	–	–	–	OK	–	–	–
100	–	–	–	–	–	OK	OK	OK	OK	–	–	–	OK	–	–	–	OK	–	–	–
80	–	–	–	–	–	OK	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
62.5	–	–	–	–	–	OK	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
50	–	–	–	–	–	–	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
40	–	–	–	–	–	–	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
31.25	–	–	–	–	–	–	OK	OK	–	–	–	–	–	–	–	–	–	–	–	–
25	–	–	–	–	–	–	–	OK	–	–	–	–	–	–	–	–	–	–	–	–
20	–	–	–	–	–	–	–	OK	–	–	–	–	–	–	–	–	–	–	–	–
15.625	–	–	–	–	–	–	–	OK	–	–	–	–	–	–	–	–	–	–	–	–

"OK"=Supported, "-"=Invalid

NOTE: There are limitations on Attitude Output depending on the output rate as shown in the following table.

Table 7-3 Output Rate Limitations

Output Rate	Gyro [0x12-1D(W0)] Accl [0x1E-29(W0)]	Attitude [0x64-6F(W0)]	Rotation Matrix [0x38-5B(W1)]	Delta [0x64-0x7B(W0)]	Range Over [0x0C,0x0D(W0)]
2000	OK	-	OK	OK	OK
1000	OK	-	OK	OK	OK
500	OK	OK(Update200sps)	OK	OK	OK
400	OK	OK(Update200sps)	OK	OK	OK
250	OK	OK(Update200sps)	OK	OK	OK
200	OK	OK	OK	OK	OK
125	OK	OK	OK	OK	OK
100	OK	OK	OK	OK	OK
80	OK	OK	OK	OK	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

7.19. 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 fc in Hz.
After setting the filter with these bits, the completion of the operation requires time period specified in Table 2-1 Filter Setting Time to elapse or confirming completion by checking **FILTER_STAT** bit 5.
NOTE: Refer to 5.7 Filter for description of filter transient response from sampling start.
NOTE: When Attitude Output is enabled (ATTI_CTRL[0x14(W1)] bit[10] = 1), the filter must be set to either one of the following:
- FIR Kaiser filter fc=100 or less or
- Moving average filter TAP=16 or more

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
01000: FIR Kaiser filter (parameter=8) TAP=32 and fc=50
01001: FIR Kaiser filter (parameter=8) TAP=32 and fc=100
01010: FIR Kaiser filter (parameter=8) TAP=32 and fc=200
01011: FIR Kaiser filter (parameter=8) TAP=32 and fc=400
01100: FIR Kaiser filter (parameter=8) TAP=64 and fc=50
01101: FIR Kaiser filter (parameter=8) TAP=64 and fc=100
01110: FIR Kaiser filter (parameter=8) TAP=64 and fc=200
01111: FIR Kaiser filter (parameter=8) TAP=64 and fc=400
10000: FIR Kaiser filter (parameter=8) TAP=128 and fc=50
10001: FIR Kaiser filter (parameter=8) TAP=128 and fc=100
10010: FIR Kaiser filter (parameter=8) TAP=128 and fc=200
10011: FIR Kaiser filter (parameter=8) TAP=128 and fc=400
10100-11111: Unused

7.20. 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.

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), etc. 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 6.1.4 UART Auto Mode Operation and 6.2 Data Packet Format. The burst output data is configured by register setting in BURST_CTRL1 [0x0C(W1)] and BURST_CTRL2 [0x0E(W1)].

7.21. 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”, check the result in **FLASH_BU_ERR** of DIAG_STAT [0x04(W0)] bit 0.

7.22. 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	QTN _OUT	ATTI _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[9] QTN_OUT
Controls the output of quaternion.
1 :Enables output.
0 :Disables outpu

bit[8] ATTI_OUT
Controls the output of attitude.
1 :Enables output.
0 :Disables output.

bit[2] GPIO_OUT
Do not use it.

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.

7.23. 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	QTN _BIT	ATTI _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

bit[9] QTN_BIT
Selects the bit length of quaternion output.
1 : 32-bit
0 : 16-bit

bit[8] ATTI_BIT
Selects the bit length of the attitude output.
1 : 32-bit
0 : 16-bit

7.24. 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 (**XDLTA**, **YDLTA**, **ZDLTA**), and delta velocity (**XDLTV**, **YDLTV**, **ZDLTV**).

1 : Inverted
0 : Not inverted

7.25. 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	7.576.E-06	2.482E-01
0001	1.515.E-05	4.965E-01
0010	3.030.E-05	9.930E-01
0011	6.061.E-05	1.986E+00
0100	1.212.E-04	3.972E+00
0101	2.424.E-04	7.944E+00
0110	4.848.E-04	1.589E+01
0111	9.697.E-04	3.178E+01
1000	1.939.E-03	6.355E+01
1001	3.879.E-03	1.271E+02
1010	7.758.E-03	2.542E+02
1011	1.552.E-02	5.084E+02
1100	3.103.E-02	1.017E+03
1101	6.206.E-02	2.034E+03
1110	1.241.E-01	4.067E+03
1111	2.482.E-01	8.134E+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	1.961.E-06	6.427E-02
0001	3.923.E-06	1.285E-01
0010	7.845.E-06	2.571E-01
0011	1.569.E-05	5.142E-01
0100	3.138.E-05	1.028E+00
0101	6.276.E-05	2.057E+00
0110	1.255.E-04	4.113E+00
0111	2.511.E-04	8.226E+00
1000	5.021.E-04	1.645E+01
1001	1.004.E-03	3.291E+01
1010	2.008.E-03	6.581E+01
1011	4.017.E-03	1.316E+02
1100	8.034.E-03	2.632E+02
1101	1.607.E-02	5.265E+02
1110	3.213.E-02	1.053E+03
1111	6.427.E-02	2.106E+03

*1) Scale Factor and Range：16bit

7.26. ATTI_CTRL Register (Window 1)

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

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

bit[11] ATTI_MODE

This bit selects the output mode when attitude output is enabled.
1 : Euler angle mode
0 : Inclination mode

bit[10:9] ATTI_ON

This bit enables or disables the Attitude Output or Delta Angle/Delta Velocity output.
00 : Disable
01 : Delta Angle/ Delta Velocity Output
10 : Attitude Output
11 : Invalid

bit[4:0] ATTI_CONV

These bits select the attitude output axis transform reference conversion.

Table 7-6 Attitude Output Axis Conversion

Register	Attitude(*1)				Euler Output(*2)			Inclination Output(*3)		Note
	Name	Forward	Left	Up	ANG1 (Roll)	ANG2 (Pitch)	ANG3 (Yaw)	ANG1	ANG2	
0x00	a	X	Y	Z	X	Y	Z	X	Y	FLU(*4) (*5)
0x01	b	X	Z	-Y	X	Z	-Y	X	Z	
0x02	c	X	-Y	-Z	X	-Y	-Z	X	-Y	
0x03	d	X	-Z	Y	X	-Z	Y	X	-Z	
0x04	e	Y	Z	X	Y	Z	X	Y	Z	
0x05	f	Y	X	-Z	Y	X	-Z	Y	X	
0x06	g	Y	-Z	-X	Y	-Z	-X	Y	-Z	
0x07	h	Y	-X	Z	Y	-X	Z	Y	-X	
0x08	i	Z	X	Y	Z	X	Y	Z	X	
0x09	j	Z	Y	-X	Z	Y	-X	Z	Y	
0x0A	k	Z	-X	-Y	Z	-X	-Y	Z	-X	
0x0B	l	Z	-Y	X	Z	-Y	X	Z	-Y	
0x0C	m	-X	Y	-Z	-X	Y	-Z	-X	Y	
0x0D	n	-X	-Z	-Y	-X	-Z	-Y	-X	-Z	
0x0E	o	-X	-Y	Z	-X	-Y	Z	-X	-Y	
0x0F	p	-X	Z	Y	-X	Z	Y	-X	Z	
0x10	q	-Y	Z	-X	-Y	Z	-X	-Y	Z	
0x11	r	-Y	-X	-Z	-Y	-X	-Z	-Y	-X	
0x12	s	-Y	-Z	X	-Y	-Z	X	-Y	-Z	
0x13	t	-Y	X	Z	-Y	X	Z	-Y	X	
0x14	u	-Z	X	-Y	-Z	X	-Y	-Z	X	
0x15	v	-Z	-Y	-X	-Z	-Y	-X	-Z	-Y	
0x16	w	-Z	-X	Y	-Z	-X	Y	-Z	-X	
0x17	X	-Z	Y	X	-Z	Y	X	-Z	Y	

*1 This is the direction that is indicated by the part marking on the device package.

*2 The Euler angle rotation order is ANG3(Yaw)→ANG1(Roll)→ANG2(Pitch). The (+) rotation direction follows the “right hand” rule.

*3 The inclination angle is referenced to the horizontal plane.

*4 The standard attitude reference and axis order for this device is Forward/Left/Up following the “right-hand rule”.

*5 When Quaternion output is enabled, set ATTI_CTRL[0x14(W1)],bit[4:0]=”00000”, ATTI_CONV: XYZ = FLU.

7.27. GLOB_CMD2 Register (Window 1)

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

Addr (Hex)	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	R/W
0x16	-	ATTI_ STAT	ATTITUDE _MOTION_PROFILE		-	-	-	-	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.

bit[6] ATTITUDE_MOTION_PROFILE_STAT

This bit returns the completion status when setting the ATTITUDE_MOTION_PROFILE.
This bit is read only.
1 : busy
0 : completed

bit[5:4] ATTITUDE_MOTION_PROFILE

The setting of this register can change the motion profile of the attitude output function. Optimal angle accuracy can be achieved by setting it according to the operating speed of the application.
The example settings are shown below. It is strongly recommended to evaluate all motion profiles to determine optimal performance.
00 : modeA
01 : modeB
10 : modeC
11 : Invalid

Table 7-7Attitude Motion Profile Description

Attitude Motion Profile	Assumed Operating Speed	Application Example
00 = modeA	3m/s	General (no specific application)
01 = modeB	20m/s	Vehicle
10 = modeC	1m/s	Construction machinery

When writing to these bits, the ATITUDE_MOTION_PROFILE_STAT changes to 1 (busy). Confirm the completion of the setting process by checking that the ATTITUDE_MOTION_PROFILE_STAT bit returns to 0.

7.28. 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 5.12 Frame Alignment Correction for more details.

7.29. 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.

7.30. VERSION Register (Window 1)

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

bit[15:0] Version
This register returns the Firmware Version

7.31. 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 0x30 or "0" (ASCII).

For example, if the Serial Number is 01234567 then the return value is:
SERIAL_NUM1 : 0x3130
SERIAL_NUM2 : 0x3332
SERIAL_NUM3 : 0x3534
SERIAL_NUM4 : 0x3736

7.32. 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. UART Sequence

8.1.1. 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.

8.1.2. 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.

8.1.3. 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,0x02,0x0d}.            /* 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,
          COUNT_Hi, COUNT_Lo, 0x0d}
   repeat (a).
  TXdata={0x83,0x02,0x0d}.            /* return to Configulation 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,0x02,0x0d}.            /* 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,
          COUNT_Hi, COUNT_Lo, 0x0d}
   repeat (a).
  TXdata={0x83,0x02,0x0d}.            /* return to Configulation 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,0x02,0x0d}.            /* 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.

   (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,
           COUNT_Hi, COUNT_Lo, 0x0d}
   repeat from (a) to (c).
  TXdata={0x83,0x02,0x0d}.        /* return to Configulation 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,0x02,0x0d}.        /* 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.

   (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,
           COUNT_Hi, COUNT_Lo, 0x0d}
   repeat from (a) to (c).
TXdata={0x83,0x02,0x0d}.        /* return to Configulation 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

8.1.4. 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.

8.1.5. 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.

8.1.6. 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.

8.1.7. 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.

8.1.8. 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).

8.1.9. 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,0x02,0x0d}.              /* 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.
(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,
            COUNT_Hi, COUNT_Lo, 0x0d}
   repeat from (i) to (ii).
(g) If you want to stop sampling,
  TXdata={0x83,0x02,0x0d}.              /* return to Configulation mode */
```

8.1.10. Attitude output (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={0x85,0x09,0x0d}.              /* 200SPS */
  TXdata={0x86,0x04,0x0d}.              /* TAP=16 */
  TXdata={0x88,0x01,0x0d}.              /* UART Auto mode */
  TXdata={0x8C,0x02,0x0d}.              /* COUNT=on,CheckSum=off */
  TXdata={0x8D,0xF1,0x0d}.              /* FLAG=on,TEMP=on,Gyro=on,ACCL=on,
                                           ATTI=on */
  TXdata={0x8F,0x71,0x0d}.              /* TEMP=32bit,Gyro=32bit,ACCL=32bit
                                           ATTI=32bit */
  TXdata={0x95,0x04,0x0d}.              /* Inclination mode, enable ATTI_ON */
  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,
            ANG1_HIGH_Hi, ANG1_HIGH_Lo, ANG1_LOW_Hi, ANG1_LOW_Lo,
            ANG2_HIGH_Hi, ANG2_HIGH_Lo, ANG2_LOW_Hi, ANG2_LOW_Lo,
            ANG3_HIGH_Hi, ANG3_HIGH_Lo, ANG3_LOW_Hi, ANG3_LOW_Lo,
            COUNT_Hi, COUNT_Lo, 0x0d}

            /* ANG3(YAW) is fixed 0 in the Inclination mode */
```

```
  repeat (a).
 TXdata={0x83,0x02,0x0d}.                    /* return to Configulation 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={0x85,0x09,0x0d}.                    /* 200SPS */
 TXdata={0x86,0x04,0x0d}.                    /* TAP=16 */
 TXdata={0x88,0x01,0x0d}.                    /* UART Auto mode */
 TXdata={0x8C,0x02,0x0d}.                    /* COUNT=on,CheckSum=off */
 TXdata={0x8D,0xF1,0x0d}.                    /* FLAG=on,TEMP=on,Gyro=on,ACCL=on,
                                                ATTI=on */
 TXdata={0x8F,0x00,0x0d}.                    /* TEMP=16bit,Gyro=16bit,ACCL=16bit
                                                ATTI=16bit */
 TXdata={0x95,0x04,0x0d}.                    /* Inclination mode, enable ATTI_ON */
 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,
            ANG1_HIGH_Hi, ANG1_HIGH_Lo,
            ANG2_HIGH_Hi, ANG2_HIGH_Lo,
            ANG3_HIGH_Hi, ANG3_HIGH_Lo,
            COUNT_Hi, COUNT_Lo, 0x0d}

            /* ANG3(YAW) is fixed 0 in the Inclination mode */
  repeat (a).
 TXdata={0x83,0x02,0x0d}.                    /* return to Configulation mode */
```

8.1.11. QUATERNION output (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={0x85,0x09,0x0d}.                    /* 200SPS */
 TXdata={0x86,0x04,0x0d}.                    /* TAP=16 */
 TXdata={0x88,0x01,0x0d}.                    /* UART Auto mode */
 TXdata={0x8C,0x02,0x0d}.                    /* COUNT=on,CheckSum=off */
 TXdata={0x8D,0xF3,0x0d}.                    /* FLAG=on, TEMP=on, Gyro=on, ACCL=on,
                                                QTN=on, ATTI=on */
 TXdata={0x8F,0x71,0x0d}.                    /* TEMP=32bit,Gyro=32bit,ACCL=32bit
                                                QTN=32bit, ATTI=32bit */
 TXdata={0x95,0x04,0x0d}.                    /* Inclination mode, enable QTN_ON,
                                                enable ATTI_ON */
```

```
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,
           QTN0_HIGH_Hi, QTN0_HIGH_Low, QTN0_LOW_Hi, QTN0_LOW_Low,
           QTN1_HIGH_Hi, QTN1_HIGH_Low, QTN1_LOW_Hi, QTN1_LOW_Low,
           QTN2_HIGH_Hi, QTN2_HIGH_Low, QTN2_LOW_Hi, QTN2_LOW_Low,
           QTN3_HIGH_Hi, QTN3_HIGH_Low, QTN3_LOW_Hi, QTN3_LOW_Low,
           ROLL_HIGH_Hi, ROLL_HIGH_Lo, ROLL_LOW_Hi, ROLL_LOW_Lo,
           PITCH_HIGH_Hi, PITCH_HIGH_Lo, PITCH_LOW_Hi, PITCH_LOW_Lo,
           YAW_HIGH_Hi, YAW_HIGH_Lo, YAW_LOW_Hi, YAW_LOW_Lo,
           COUNT_Hi, COUNT_Lo, 0x0d}

    /* YAW is fixed 0 in the Inclination mode */
    /* Quaternion is fixed point with upper 2 bits (signed) integer and lower 30 bits decimal */
```

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.
- 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 to check the effect of the supply voltage drop by inrush current in the system.
- 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 using the product for those applications.
- Do not alter or disassemble the product.

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 connecting the product to a CAN bus network, do not turn on the supply voltage.
- Do not use the product in a situation where power is always applied to the joint of connector.
- You must wire signals correctly with attention to the name and the polarity of each signal.
- The power supply to this product must satisfy the voltage rating within 2 seconds after it is turned on.
- Do not use thinner or similar liquids on this product. When cleaning this product, alcohol may be used.
- Total length of cables should be less than the maximum total length of cable defined in table 4.1. It is recommended that the cable satisfy the EIA standard.
- Uqjfxj%it%ymj%|nwnsl%|twp%|nym%ymj%ut|jw%tk%ymj%jvznurjsy%yzwsji%tkk3

10. PART NUMBER / ORDERING INFO

The following is the ordering code for the product:

Product Type	Product Name	Product Code
IMU for RS422 Interface	M-G552PR10	X2G000121000700

11. STANDARDS AND APPROVALS

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

11.1. NOTICE

This is a Class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.
The connection of a non-shielded interface cable to this product will invalidate the EMC standards of the device.
Any changes or modifications not expressly approved by Seiko Epson Corporation could void your authority to operate the equipment.

11.2. CE Statement

This product conforms to the following Directives and Norms,

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

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

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

11.3. RoHS & WEEE

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

AEEE Yönetmeliğine Uygundur.

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

11.4. UKCA Statement

This product conforms to the following Directives and Norms,

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

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

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

11.5. FCC Compliance Statement for American users

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

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

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

11.6. Industry ICES Compliance Statement for Canadian users

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

12. REVISION HISTORY

Attachment-1

Rev. No.	Date	Page	Category	Contents
Rev.1.0	Dec. 2020	All	New	New
Rev.1.1	Jun. 2021	1,5	Modify	unit change of Gyro Characteristics °/s → °/h
Rev.1.2	Apr. 2022	75	Modify	Product number Change Old Product Number: E91E620140, ~2022/3/31 New Product Number: X2G000121000700, 2022/4/1~
Rev.1.3	Dec. 2022	66/70 75	Modify	Deleted Sample Flow 3/4 (UART burst mode) seq (a) in 8.1.3 and seq (i) in 8.1.9 due to typo UKCA compliance and regulatory amendments
Rev.1.4	Jul. 2023	cover	Modify	Corporate logo change

EPSON

International Sales Operations

AMERICA

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

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

EUROPE

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

ASIA

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

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

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

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

JAPAN

SEIKO EPSON CORPORATION.

https://global.epson.com/products_and_drivers/sensing_system/contact/

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