

IMU (Inertial Measurement Unit) - CAN Interface

M-G552PJ1x

Data Sheet

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1. Overview

The M-G552PJ is a small form factor inertial measurement unit (IMU) with 6 degrees of freedom: triaxial angular rates and linear accelerations and provides high-stability and high-precision measurement capabilities with the use of high-precision compensation technology.

The M-G552PJ1 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 a 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 Controller Area Network (CAN) interface support for host communication, the M-G552PJ 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 to use for 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 16bit data resolution Calibrated stability (Bias, Scale factor, Axial alignment)	
Output data rate	100 sps (Default) Up to 200 sps (When attitude angle output is enabled) Up to 1000 sps (When attitude angle output is disabled)	
LPF	Built-in moving average filter and FIR Kaiser filter	
Interface		
Protocol	J1939 compatible	
Physical layer	ISO11898-2 (High speed CAN)	
Frame format	CAN2.0B 29 bit-ID	
Bit rate	250k bps or 500k bps	
Node-ID	128	programmable by CAN_ADDR register setting
Other function		
Indicator	Green-LED / Red-LED	
General specification		
Voltage supply	9 V to 32 V	

Item		Specification	Note
	Power consumption	32 mA	12V, default setting
	Operating temperature range	-30 °C to +80 °C	
External dimension			
	Outer packaging	Overall metallic shield case	
	Size	65 x 60 x 30 mm ³ (Not including projection.)	
	Weight	115 g	
	Interface connector	CAN connector: 5-pos, M12, waterproof	
	Water-proof, Dust-proof:	IP67 equivalent	
Regulation (Applicable only for Mass production)			
	EU	CE marking (EN61326/RoHS Directive) Class A	
	USA	FCC part15B Class A	

1.2. Block Diagram

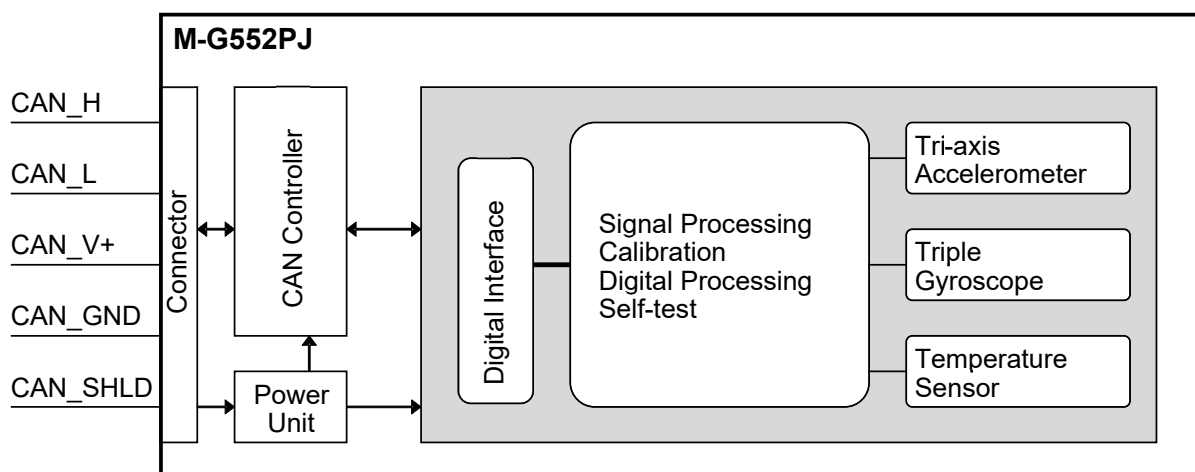


Figure 1-1 Functional Block Diagram

2. Specifications

2.1. Absolute Maximum Ratings

Table 2-1 Absolute Maximum Rating

Parameter	Term	Conditions	Range	Unit
Power supply voltage	V _{IN}	CAN_V+ to CAN_GND	-0.3 ~ +32V	V
Port input voltage	V _{port}	CANH/CANL to CAN_GND	-32 ~ +32	V
Storage temperature	T _{STG}		-40 ~ +85	°C
Operating temperature ¹	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 \pm 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

T_a=25°C, V_{in}=12V, R_L=60Ω, unless otherwise specified; all voltages are defined with respect to ground

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Power supply voltage	V _{IN}	CAN_V+ to CAN_GND (*1)	9 ^(*2)	12 (24)	30	V
Port input voltage	V _{PORT}	CANH/CANL 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) When power supply voltage is 9V or less, the master may not be able to communicate with this node normally even if the green LED turns on.

2.3. Electrical Characteristics

Table 2-3 Sensor Characteristics

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

Parameter	Test Conditions / Comments	Min.	Typ.	Max.	Unit
Gyroscope					
Sensitivity					
Output range		—	± 450	—	°/s
Scale factor		Typ-0.2%	0.0151515	Typ+0.2%	(°/s)/LSB
Non-linearity (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, $\Delta = 90^{\circ}$ ideal	—	0.01	—	°
Bias					
Initial error	1 σ , $-30^{\circ}\text{C} \leq T_A \leq +80^{\circ}\text{C}$	—	360	—	°/h
Repeatability	1 σ , turn-on to turn-on *2	—	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		Typ-0.1%	0.4	Typ+0.1%	mG/LSB
Non-linearity (Best fit straight line)	1 σ , $\leq 5\text{G}$	—	0.1	—	% of FS
Misalignment	1 σ , Axis-to-axis, $\Delta = 90^{\circ}$ ideal	—	0.01	—	°
Bias					
Initial error	1 σ , $-30^{\circ}\text{C} \leq T_A \leq +80^{\circ}\text{C}$	—	4	—	mG
Repeatability	1 σ , turn-on to turn-on *2	—	3	—	mG
Bias instability	Average	—	16	—	uG
Velocity random walk	Average	—	0.033	—	(m/s)/√h
Noise density	f = 10 to 20 Hz	—	80	—	uG/√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	°
Scale factor	16bit	—	0.01	—	°/LSB
Accuracy*4	1 σ , Static	—	0.2	—	°
	1 σ , Dynamic (100°/s, max) *3	—	0.2	—	°
Temperature Sensor					
Scale factor *1	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) Turn-on to turn-on / Day by day, estimated variation during 5 consecutive days.

*3) This specification is based on measurement data that has been measured from a static condition.

*4) This specification is based on the measurement data of Motion Profile: mode A.

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 Function Execution Times

Parameter	Term	Description	Min.	Typ.	Max.	Unit
Power-on boot-up time	t_{BT}	Time to boot-up completion from power on.	-	-	800	msec
Software-reset boot-up time	t_{SR2BT}	Time to boot-up completion from software-reset.	-	-	800	msec
Enter sampling-mode time	-	Time to sampling mode from configuration mode.	-	-	600	msec
Save-parameter time	-	Save-parameter execution time	-	-	200	msec
Restore-default-parameter time	-	Restore-default-parameter execution time	-	-	100	msec
Self-test time	-	Self-test execution time	-	-	100	msec
IMU self-test time	-	IMU self-test execution time	-	-	600	msec
Preset zero time	-	Preset zero execution time	-	-	1200	msec
Preset cancel time	-	Preset cancel execution time	-	-	10	msec

Table 2-5 CAN Characteristic

$T_a=25^\circ\text{C}$, $V_{in}=12\text{V}$, $R_L=60\Omega$, unless otherwise specified; all voltages are defined with respect to ground; positive currents flow into the sensor unit.

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Output voltage (dominant)	$V_O(\text{dom})$	CANH	2.75	3.5	4.5	V
		CANL	0.5	1.5	2.25	V
Output voltage (recessive)	$V_O(\text{rec})$	CANH/CANL	2	2.5	3	V
Differential output voltage(dominant)	$V_O(\text{dif})_{\text{dom}}$	CANL to CANH	1.5	-	3	V
Differential output voltage(recessive)	$V_O(\text{dif})_{\text{rec}}$	CANL to CANH	-120	-	12	mV
Output current (dominant)	$I_{OS}(\text{dom})$	CANL=open; $V_{CANH}=+0.3\text{V}$	-100			mA
		CANH=open; $V_{CANL}=+32\text{V}$			100	mA
Output current (recessive)	$I_{OS}(\text{rec})$	$V_{CANH}=V_{CANL}$	-5	-	5	mA

Table 2-6 Current Consumption

$T_a=25^\circ\text{C}$, $R_L=60\Omega$, unless otherwise specified; all voltages are defined with respect to ground; positive currents flow into the sensor unit; Sampling mode; Sensor sample rate 100Sps

Parameter	Term	Condition	Min.	Typ	Max.	Unit
Mean current in measurement state	$I_{IN}(\text{sampling})$	$V_{in}=12\text{V}$, 250kbps, default	-	32	-	mA
		$V_{in}=24\text{V}$, 250kbps, default	-	18	-	mA
Mean current in idle state	$I_{IN}(\text{config})$	$V_{in}=12\text{V}$, Config mode	-	29	-	mA
		$V_{in}=24\text{V}$, Config mode	-	16.5	-	mA
Maximum input current	$I_{IN}(\text{max})$		-	-	60.0	mA

2.4. Connector Specification

Table 2-7 Connector specification

Model number	SACC-DSI-MS-5CON-M12-SCO SH(X)
Manufacturer	PHOENIX CONTACT

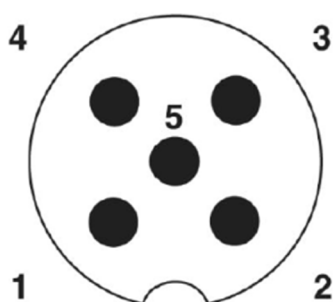


Figure 2-1 Terminal Layout

Table 2-8 Terminal Function

No	Pin Name	I/O	Description
1	CAN_SHLD	-	CAN shield (*1)
2	CAN_V+	I	External power supply (9-32V)
3	CAN_GND	-	Ground
4	CAN_H	I/O	CAN H bus line
5	CAN_L	I/O	CAN L bus line

Notice: This unit should be connected to a connector that satisfies at least the IP67 waterproof and dustproof specification.

(*1) CAN_SHLD is connected to the case.

2.5. Mechanical Dimensions

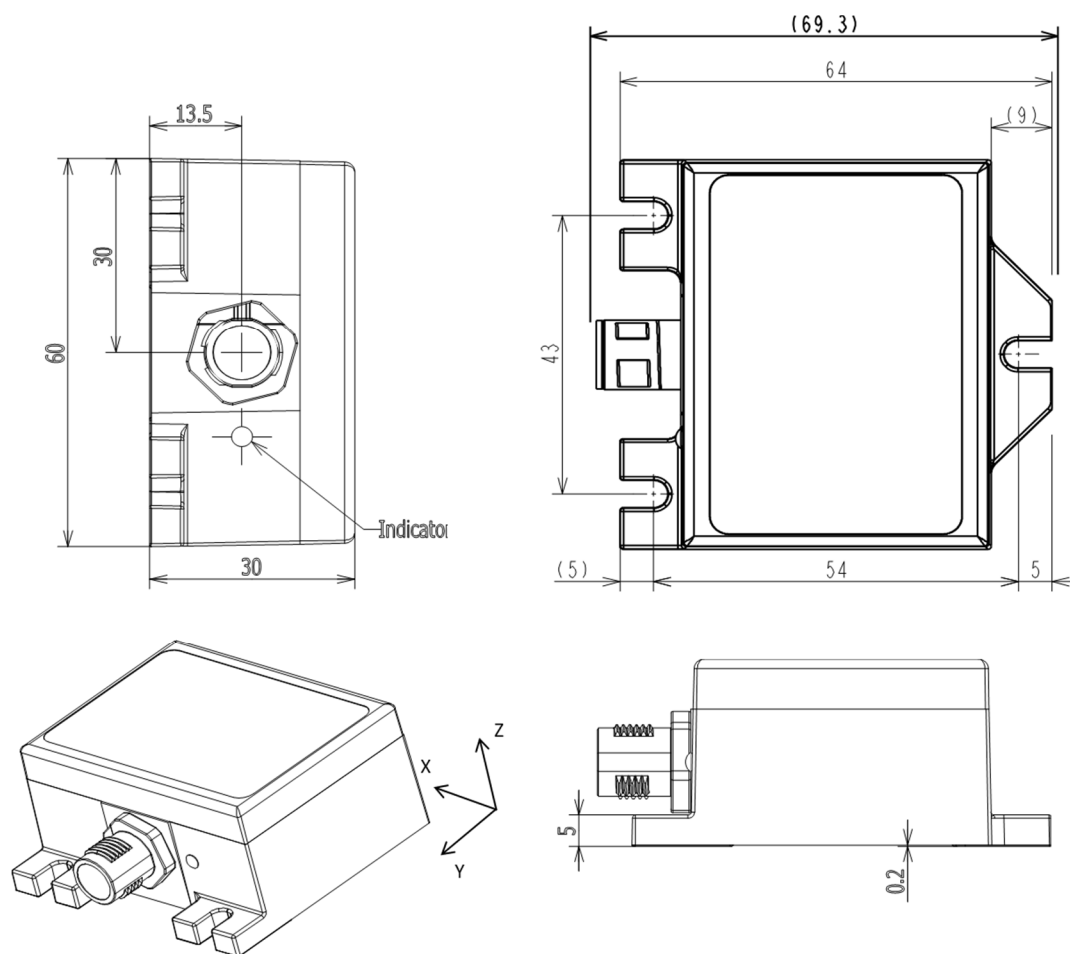


Figure 2-2 Outline Dimensions (millimeters)

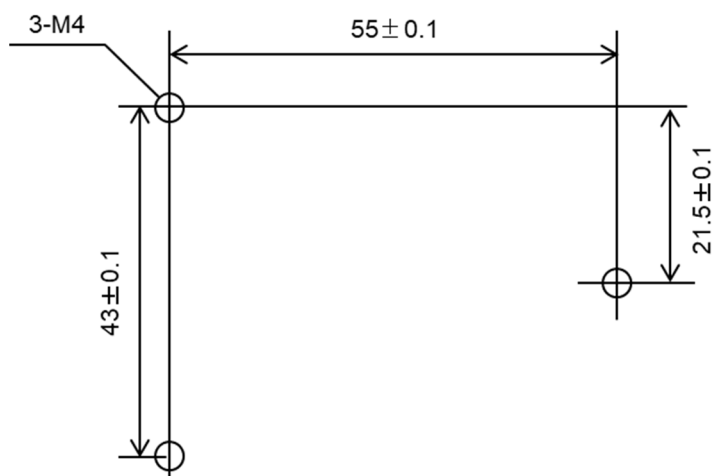


Figure 2-3 Recommended Mounting Dimensions (millimeters)

3. Typical Characteristics

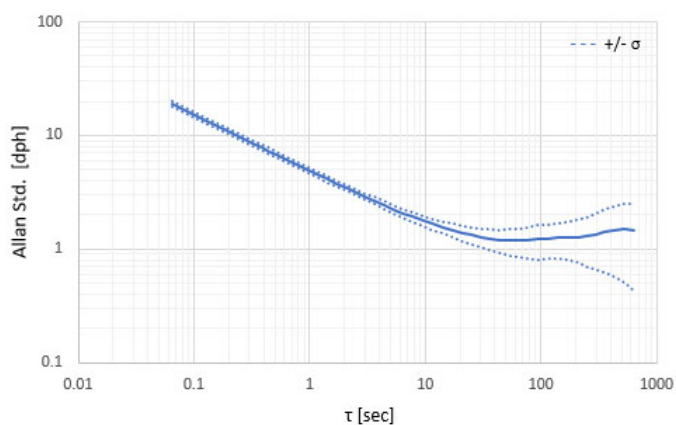


Figure 3-1 Gyro Allan Variance Characteristic

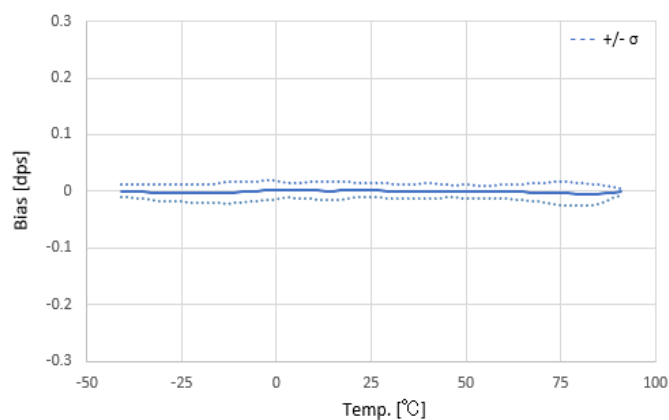


Figure 3-2 Gyro Bias vs. Temperature Characteristic

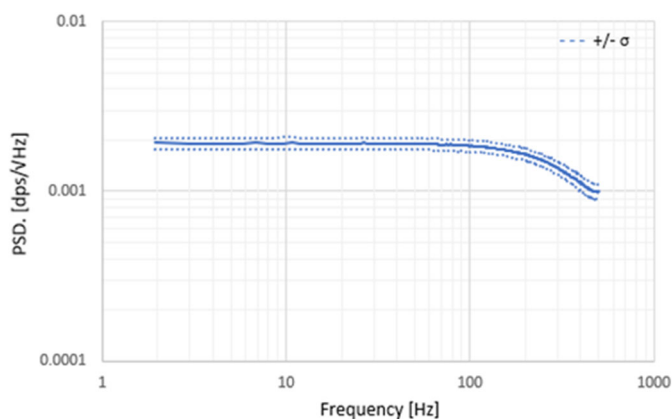


Figure 3-3 Gyro Noise Frequency Characteristic

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

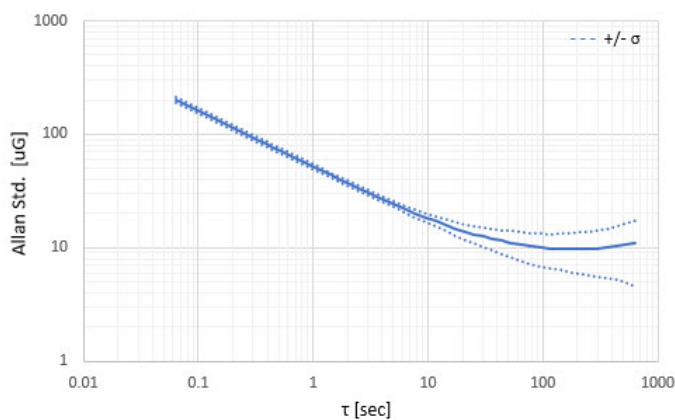


Figure 3-4 Accelerometer Allan Variance Characteristic

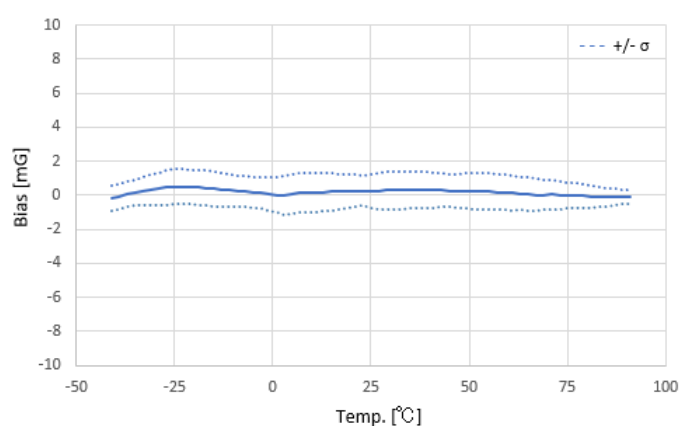


Figure 3-5 Accelerometer Bias vs. Temperature Characteristic

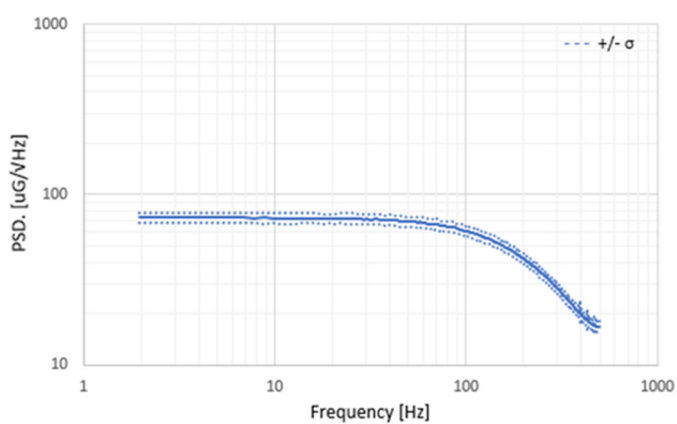


Figure 3-6 Accelerometer Noise Frequency Characteristic

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

4. Connection Example

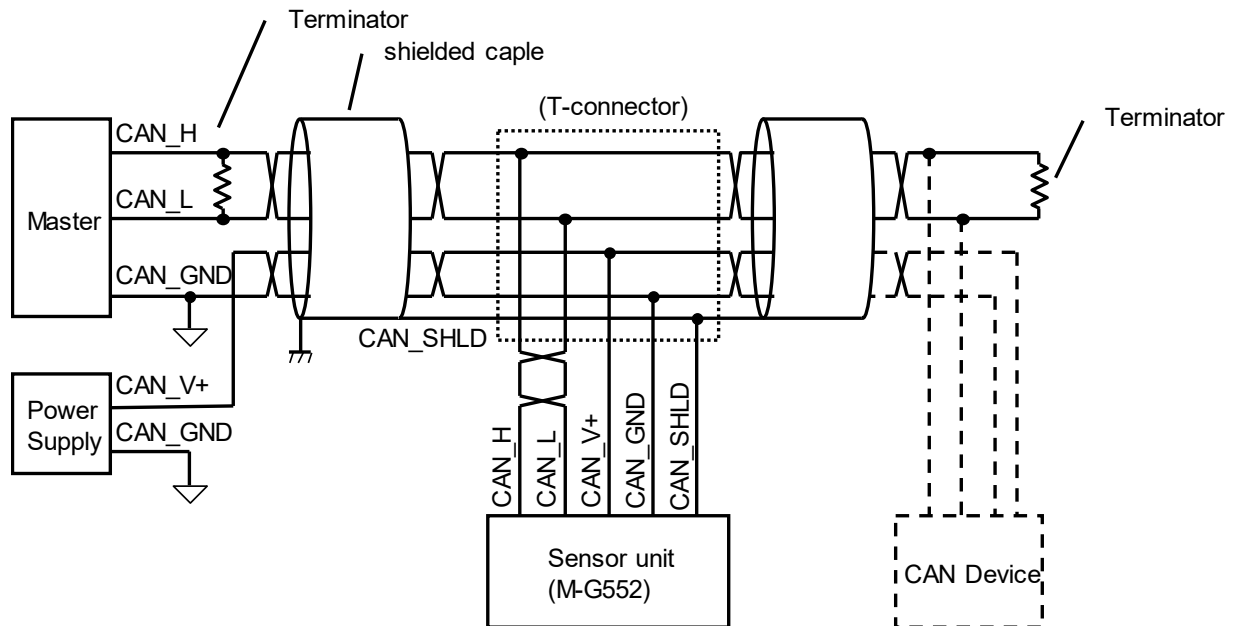


Figure 4-1 Connection Example

4.1. PRECAUTIONS FOR WIRING AND CABLING

- This product has no internal terminator.
The user is required to connect a terminator at both ends of the cable segment.
- It is recommended that shield connects to ground.
- It is recommended that the cable meets the requirements of the CAN standard.
- Refer to table 4.1 which defines the maximum practical length of cable wiring in a CAN network. Communication may be unstable depending on system environment even if the system satisfies Table 4.1.

Table 4-1 Maximum Recommended Total Length of Cable (Reference)

CAN bitrate	Max bus length
250kbps	40m

4.2. PRECAUTIONS 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 4-2 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: CAN_V+ (Power supply)
PGND: CAN_GND (Power supply ground)

FGND: EARTH (System ground earth)
 U3039: Surge absorber to power supply ground (Okaya Electric Industries)
 ERZ-V14D390: Surge absorber to earth ground (Panasonic)

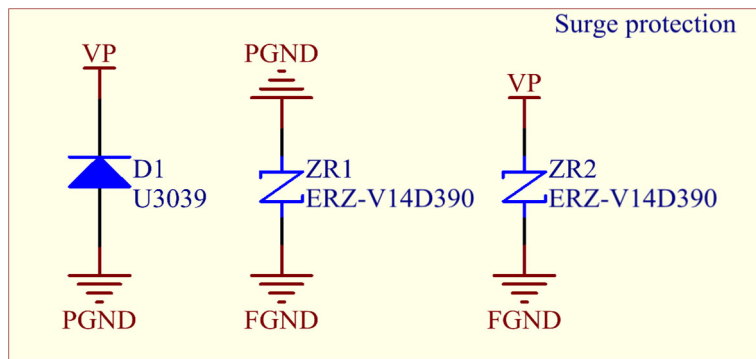


Figure 4-2 Surge Protection Circuit

5. Functional Description

5.1. Operation Mode

The device has the following two operation modes.

- (1) Configuration Mode
- (2) Sampling Mode

Immediately after a hardware reset or power-on, internal initialization starts. During the internal initialization, messages to the device will not be processed. After the internal initialization is completed, the device goes into the Sampling mode from the Configuration mode. During the Sampling mode, angular rate, and acceleration data are transmitted periodically as SOUT messages.

Configure various operational settings in the Configuration mode. To change the operation mode, write to the MODE_CMD (bit[3:0] of the MODE_CTRL of the MODE register). When software reset is executed (by writing 0x3 to the MODE_CMD (bit[3:0] of the MODE_CTRL of the MODE register)), internal initialization is executed and then the device goes into the Sampling mode regardless of the current operation mode.

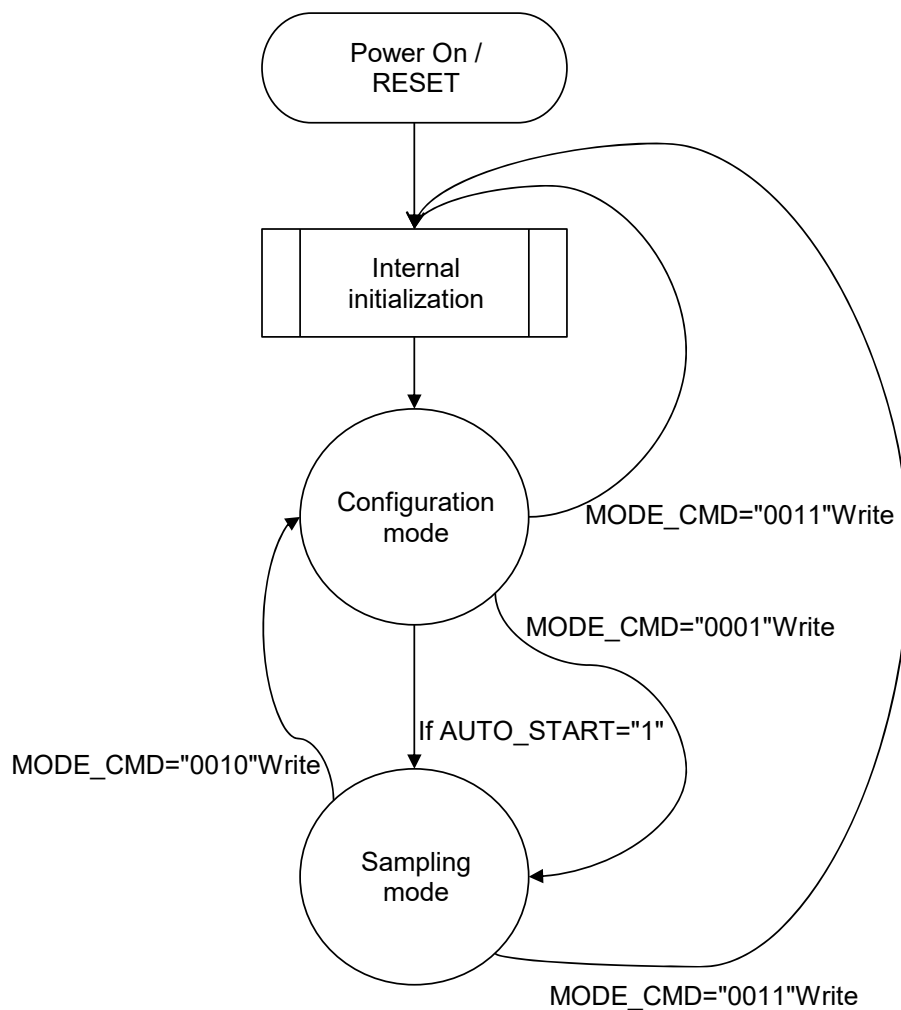


Figure 5-1 Operational State Diagram

5.2. 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_SEL" setting of CONFIG2 Register [06h] register.

(1) Moving Average Filter:

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

Figure 5-2 shows the characteristics of this filter.

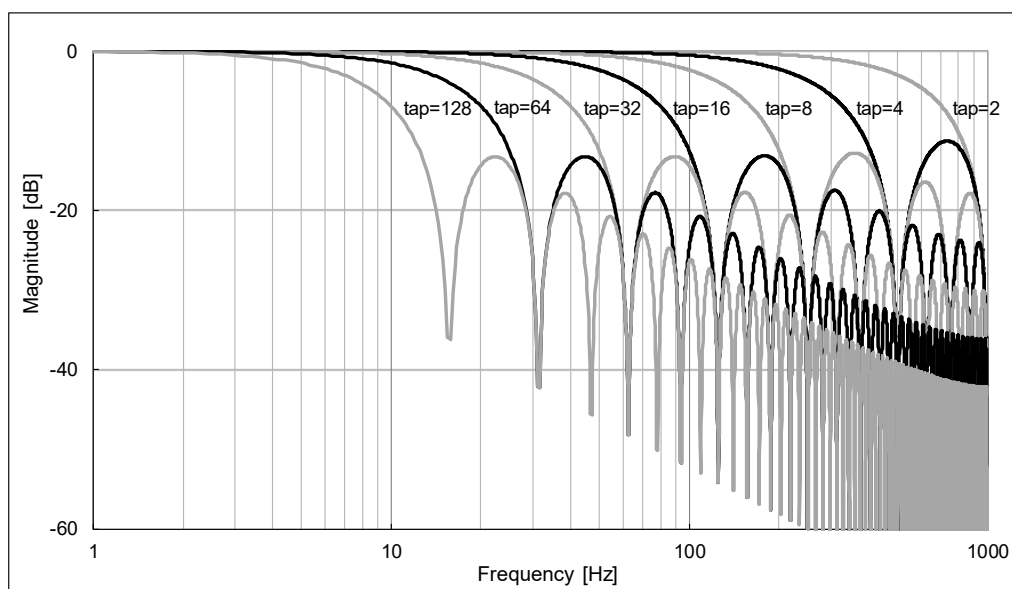


Figure 5-2 Moving Average Filter Characteristics

(2) FIR Kaiser filter:

Uses Kaiser Window(parameter=8)

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

Figure 5-3 and Figure 5-4 show the typical characteristic of this filter.

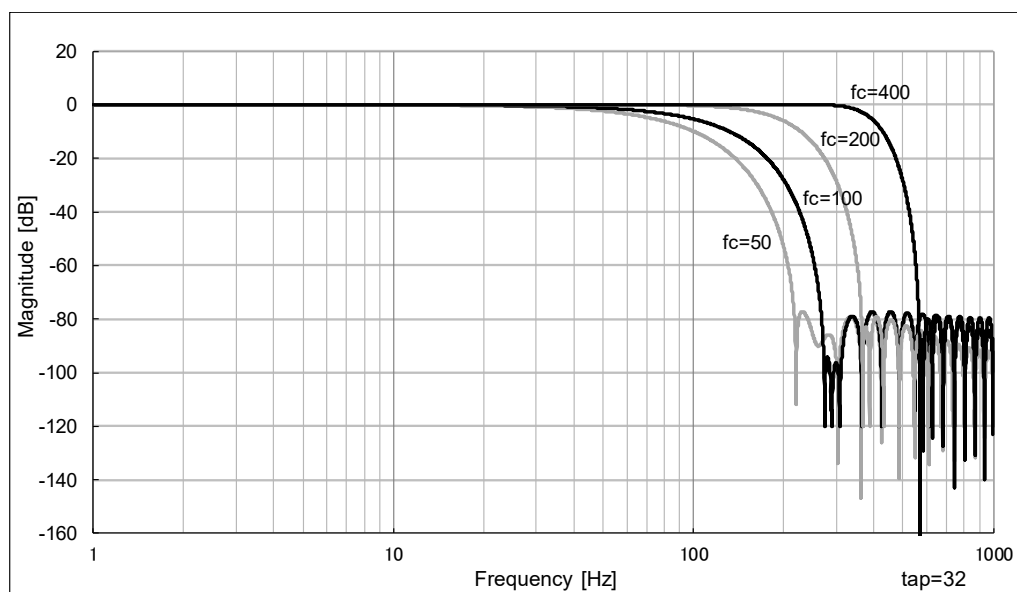


Figure 5-3 FIR Kaiser Filter Characteristic (tap=32)

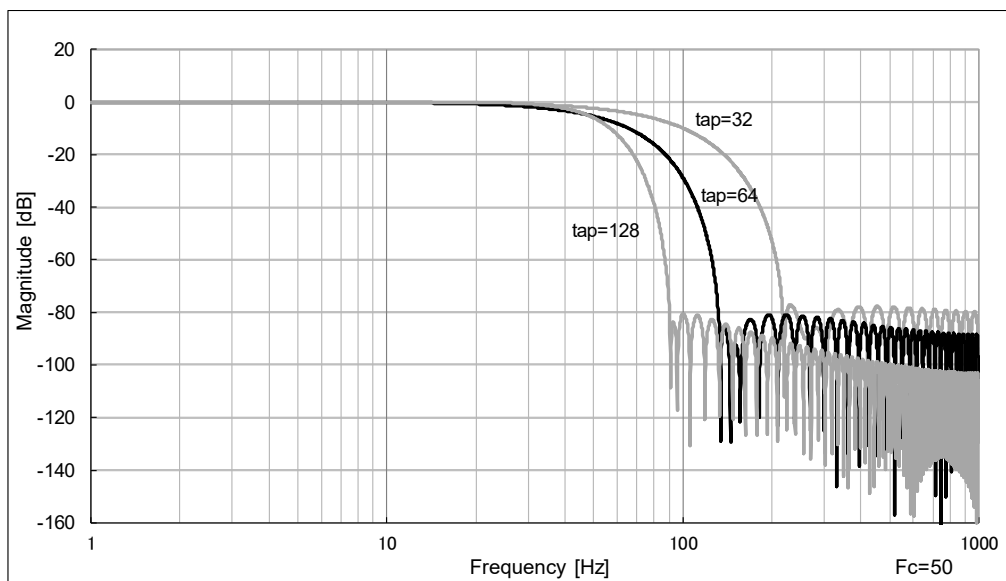


Figure 5-4 FIR Kaiser Filter Characteristic (Fc=50Hz)

Please note that the transient response of the digital filter is a maximum of 63 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

	TAP2	TAP4	TAP8	TAP16	TAP32	TAP64	TAP128
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
50sps						1	3
25sps							1

5.3. Reference Attitude

The reference attitude can be changed by BASE_ATT1 (bit[7:3] of ATT1_CTRL of the CONFIG2 register), in configuration mode.

Table 5-2 BASE_ATT1 Settings

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

(*1) Direction of X, Y, and Z are marked on the casing of this device.

(*2) Euler angle output indicates the angle to rotate about each axis center in the order of ANG 1 (Roll) and ANG 2 (Pitch). The direction of rotation (+) is the right-hand screw direction.

(*3) Inclination angle output indicates the minimum angle that each axis makes with the horizontal plane.

5.4. Attitude Motion Profile

The attitude motion profile can be changed by ATTI_MOTION_PROFILE (bit[1:0] of ATTI_CTRL2 of the CONFIG2 register), in configuration mode.

Optimal angle accuracy can be achieved by setting according to the operating speed of the application. It is strongly recommended to evaluate all motion profiles to determine optimal setting.

Table 5-3 ATTI_MOTION_PROFILE Settings

Register settings	Estimated operating speed	Application example
0x0: mode A	3m/s	General purpose (no specific application is expected)
0x1: mode B	20m/s	Vehicle
0x2: mode C	1m/s	Construction machinery

5.5. Inclination Angles

To enable inclination angle output, configure the following register setting in Configuration mode, then shift to the Sampling mode.

CONFIG2 Register, ATTI_CTRL bit[1] "EULER_EN=0" and bit[0] "ATTI_EN=1"

The inclination angle data are transmitted periodically as SOUT7 messages.

The inclination angle output shows the minimum angle that each axis makes with the horizontal plane.

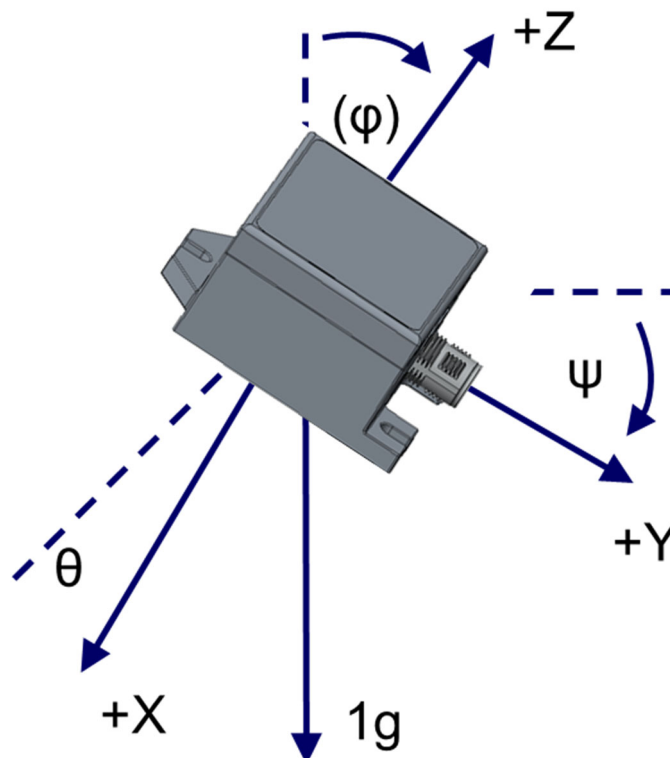


Figure 5-5 Inclination Angle

θ: ANG1[15:0] Attitude angle data 1
 Ψ: ANG2[15:0] Attitude angle data 2

Register setting: CONFIG2[06h], ATTI_CTRL bit[7:3] BASE_ATT1, and select attitude "a"

5.6. Euler Angles

To enable Euler angle output, configure the following register setting in Configuration mode, then shift to the Sampling mode.

CONFIG2 Register, ATTI_CTRL bit[1] "EULER_EN=1" and bit[0] "ATTI_EN=1"

The Euler angle data are transmitted periodically as SOUT7 messages.

Euler angle output indicates the angle to rotate about each axis center in the order of ANG 1 (Roll) and ANG 2 (Pitch). The direction of rotation (+) is the right-hand screw direction.

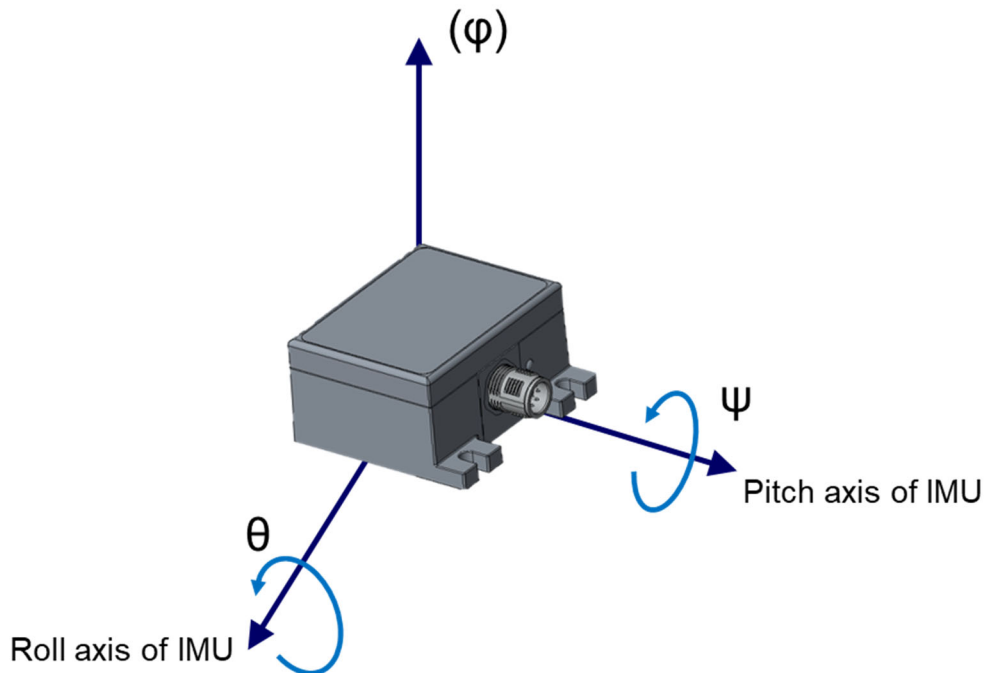


Figure 5-6 Euler Angle

θ : ANG1[15:0] Attitude angle data 1

Ψ : ANG2[15:0] Attitude angle data 2

Register setting: CONFIG2[06h], ATTI_CTRL bit[7:3] BASE_ATT1 set to attitude "a"

5.7. Preset Zero

In the Configuration mode, execute the "attitude angle preset zero" (register: MSC_CMD [0x04], write "0x05" to the MSC1 byte) to set the current attitude angle output to zero. The current attitude angle data at the time of attitude angle preset zero execution can be read from the ATTI_PSET0 register.

5.8. Preset

In Configuration mode, the current attitude angle output can be preset to any attitude angle by writing a value to the ATTI_PSET register.

An example of the preset usage is shown below where 3 IMUs are individually mounted on each link of a 3 jointed beam:

- Basic attitude that attitude angle of sensor becomes arbitrary angle①(static state in Figure 5-7)
- Set "arbitrary attitude angle" in the PRESET execution flow (Figure 5-8)
- The "arbitrary attitude angle" set in basic attitude① is output from this sensor.

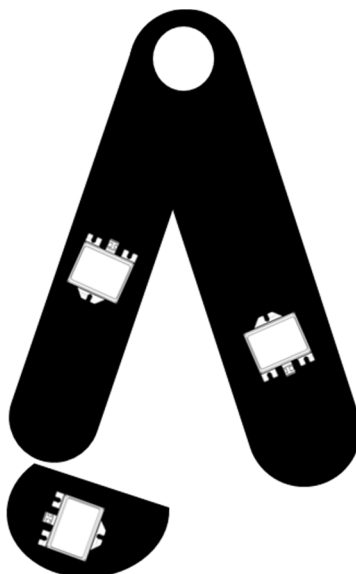


Figure 5-7 Basic attitude①

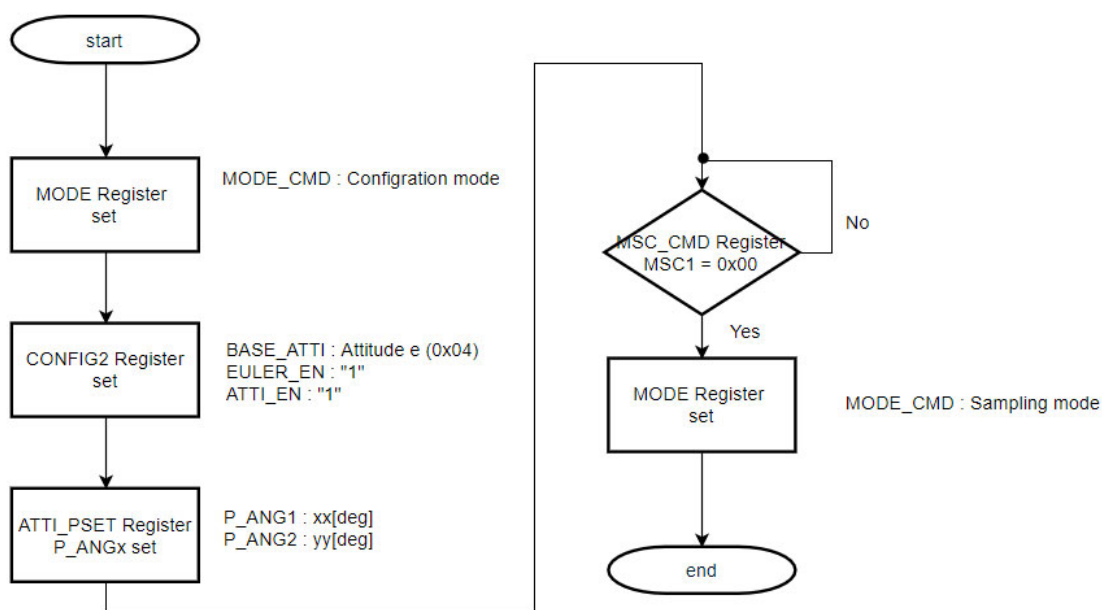


Figure 5-8 PRESET Execution flow

5.9. Offset

In Configuration mode, any offset angle can be added to the current attitude by setting the ATTI_OSET register.

6. Host Interface

The device interface and communication messaging format are in accordance to J1939.

6.1. Overview

Table 6-1 Communication Settings

Item	Value	Note
CAN Bit Rate	250k bps / 500k bps	
CAN 29bit ID	-	CAN 11bits ID is ignored.
Address	128 (0x80)	Address is programmable by CAN_ADDR register

Table 6-2 Name Field

Field Name (J1939)	No. of bits	Byte No.	Value	Description
Arbitrary Address Capable	1	8	1	"Arbitrary Address Capable"
Industry Group	3	8	0	"Global"
Vehicle System Instance	4	8	0	
Vehicle System	7	7	0	"Non-specific System"
Reserved	1	7	0	
Function	8	6	145 (dec)	"Inertial Sensor"
Function Instance	5	5	0	
ECU Instance	3	5	2	
Manufacturer Code	11	4,3	650 (dec)	"Seiko Epson Corp."
Identity Number	21	3,2,1	xxxx	Unique number

Table 6-3 Predefined Messages

Message Name	Direction	Priority	PGN	Description
Address Claimed	in/out	6	60928 (0x00EE00)	Claim an address to use.

Table 6-4 Proprietary Messages

Message Name	Direction	Priority	PGN	Description
Command	input	6	61184 (0x00EF00)	Command to the device.
Response	output	6	65504 (0x00FFE0)	Response for a command from the device.
SOUT1	output	6	65505 (0x00FFE1)	Angular rate data output
SOUT2	output	6	65506 (0x00FFE2)	Acceleration data output
SOUT4	output	6	65508 (0x00FFE4)	Temperature data output
SOUT5	output	6	65509 (0x00FFE5)	Time data output
SOUT7	output	6	65511 (0x00FFE7)	Attitude angle data output

6.2. Messages

6.2.1. Address Claimed Message (PGN 60928)

Name	29bit ID				Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Address Claimed	0x18	0xEE	0xFF	SA (0x80)	Name[64bit]							

The device sends this message out to claim an address to use at boot-up.

6.2.2. Command Message (PGN 61184)

Name	29bit ID				Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Command	0x18	0xEF	DA (0x80)	SA (8bit)	R/W	ADDR	DATA [7:0]	DATA [15:8]	DATA [23:16]	DATA [31:24]	DATA [39:32]	DATA [47:40]

Host equipment can control the IMU by accessing the control registers inside the device by using the command message.

When R/W byte is 00h, it means register read, 80h means register write.

The ADDR byte sets the register address to be accessed.

The DATA byte sets the data to be written to the register at the time of register write and all "0" at the register read.

R/W[7:0] Read/Write specifier
 00h: Read request
 80h: Write request
 ADDR[7:0] Register address
 DATA[47:0] Write data @write request
 0x000000000000 @read request

6.2.3. Response Message (PGN 65504)

Name	29bit ID				Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
Response	0x18	0xFF	0xE0	SA (0x80)	STS	ADDR	DATA [7:0]	DATA [15:8]	DATA [23:16]	DATA [31:24]	DATA [39:32]	DATA [47:40]

The message is transmitted out as a response from the command message.

When the STS byte is 00h or 80h, it indicates that the command completed normally. Other values indicate error.

The ADDR byte contains the address specified from the Command message. In the DATA byte, all zeros are returned when register write is performed, and the read register value is returned when a register read is performed.

The meaning of the error code entering the STS byte depends on each command.

STS[7:0] Status for Command message
 00h: Read success
 80h: Write success
 01h, 02h, 03h, .. : Read error
 81h, 82h, 83h, .. : Write error
 ADDR[7:0] Register address
 DATA[47:0] 0x000000000000 @write request
 Read data @read request

6.2.4. SOUT1 Message (PGN 65505)

Name	29bit ID				Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
SOUT1	0x18	0xFF	0xE1	SA (0x80)	CNT [7:0]	ERR_ FLAG	GX [7:0]	GX [15:8]	GY [7:0]	GY [15:8]	GZ [7:0]	GZ [15:8]

Angular rate data is transmitted periodically as SOUT1 messages.

CNT[7:0] Sampling counter value
 ERR_FLAG[7:0] Error flag
 GX[15:0] Gyroscope output data(x-axis)
 GY[15:0] Gyroscope output data(y-axis)
 GZ[15:0] Gyroscope output data(z-axis)

The sampling count value contains an integer value that increments by 1 from 0 to 255 (= 0xFF). After 255, the sampling count returns to 0. The same sampling count value is entered in the SOUTx message at the same time, so it is possible to time correlate the sample data.

The error flag contains the values of register ERROR [01h], ERR_FLAG byte. For details, refer to the explanation of register ERROR.

The gyroscope output data is in straight binary format. Please refer to the below formula for conversion to angular rate in degrees/second. The scale factor is 1/66=0.0151515 [(deg/s)/LSB]. The offset value is -450 [deg/s].

$$G \text{ [deg/s]} = SF * B + O$$

SF: Scale Factor

B: Gyroscope output data (decimal)

O: Offset value [deg/s]

When the range of +/- 450 [deg / s] is exceeded, error data 0xFF00 is output.

6.2.5. SOUT2 Message (PGN 65506)

Name	29bit ID				Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
SOUT2	0x18	0xFF	0xE2	SA (0x80)	CNT [7:0]	ERR_ FLAG	AX [7:0]	AX [15:8]	AY [7:0]	AY [15:8]	AZ [7:0]	AZ [15:8]

Acceleration data are transmitted periodically as SOUT2 messages.

CNT[7:0] Sampling counter value
 ERR_FLAG[7:0] Error flag
 AX[15:0] Accelerometer output data(x-axis)
 AY[15:0] Accelerometer output data(y-axis)
 AZ[15:0] Accelerometer output data(z-axis)

The sampling count value is the same as SOUT1.

The error flag contains the values of register ERROR [01h], ERR_FLAG byte. For details, refer to the explanation of register ERROR.

The accelerometer output data is in straight binary format. Please refer to the below formula for conversion to linear acceleration in milli-G. The scale factor is 0.4 [mG]. The offset value is -10000 [mG].

$$A \text{ [mG]} = SF * C + O$$

SF: Scale Factor

C: Acceleration sensor output data (decimal)

O: Offset value [mG]

When the range of +/- 450 [deg / s] is exceeded, error data 0xFF00 is output.

6.2.6. SOUT4 Message (PGN 65508)

Name	29bit ID				Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
SOUT4	0x18	0xFF	0xE4	SA (0x80)	CNT [7:0]	ERR_ FLAG	TEMP [7:0]	TEMP [15:8]	-	-	-	-

Temperature data are transmitted periodically as SOUT4 messages.

CNT[7:0] Sampling counter value

ERR_FLAG[7:0] Error flag

TEMP[15:0] Temperature sensor output data

The sampling count value is the same as SOUT1.

The error flag contains the values of register ERROR [01h], ERR_FLAG byte. For details, refer to the explanation of register ERROR.

The temperature data is a 16-bit two's complement representation. Please refer to the below formula for conversion to temperature in centigrade. The scale factor is -0.0037918 [°C/LSB]. The output data value at 25 [°C] is 2634.

$$T [^{\circ}\text{C}] = \text{SF} * (\text{E} - 2634) + 25$$

SF: Scale Factor

E: Temperature sensor output data (decimal)

The temperature data is a reference value used for internal temperature compensation. There is no guarantee that the value gives an absolute value of the internal temperature.

6.2.7. SOUT5 Message (PGN 65509)

Name	29bit ID				Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
SOUT5	0x18	0xFF	0xE5	SA (0x80)	CNT [7:0]	ERR_ FLAG	MS [7:0]	MS [15:8]	MS [23:16]	MS [31:24]	DY [7:0]	DY [15:8]

The acquisition time of the sensor data (SOUTx) with the same sampling count value is output periodically. The sensor data (SOUTx) acquisition time means the internal time of the device when the sensor data is acquired from the built-in IMU. The internal time of this device can be set to any value by register TIME.

CNT[7:0] Sampling counter value

ERR_FLAG[7:0] Error flag

DY[15:0] Day

MS[31:0] Millisecond

The sampling count value is the same as SOUT1.

The error flag contains the values of register ERROR [01h], ERR_FLAG byte. For details, refer to the explanation of register ERROR.

DY is the day when the sensor data (SOUTx) was acquired.

MS is the millisecond (resolution is 1/16ms = 62.5us unit) of the sensor data (SOUTx) acquisition time.

This message cannot be output by itself. Be sure to set to output with one of the sensor data.

6.2.8. SOUT7 Message (PGN 65511)

Name	29bit ID				Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
SOUT7	0x18	0xFF	0xE7	SA (0x80)	CNT [7:0]	ERR_ FLAG	ANG1 [7:0]	ANG1 [15:8]	ANG2 [7:0]	ANG2 [15:8]	-	-

Attitude angle data are transmitted periodically as SOUT7 messages.

CNT[7:0] Sampling counter value

ERR_FLAG[7:0] Error flag

ANG1[15:0] Attitude angle data 1(Refer to 5.3 Reference Attitude)

ANG2[15:0] Attitude angle data 2(Refer to 5.3 Reference Attitude)

The sampling count value is the same as SOUT1.

The error flag contains the values of register ERROR [01h], ERR_FLAG byte. For details, refer to the explanation of register ERROR.

The attitude angle output data is in straight binary format. For the conversion to angles in degrees, refer to the following formula. The scale factor is 0.01 [deg/LSB]. The offset value is -320 [deg].

$$\text{ANG [deg]} = \text{SF} * \text{D} + \text{O}$$

SF: Scale Factor

D: Attitude angle data (decimal)

O: Offset value [deg]

The attitude angle output mode can be selected from the following two by setting EULER_EN (register CONFIG2 [0x03], ATTI_CTRL byte).

- Inclination angle output
- Euler angle output

When the following range is exceeded, error data 0xFF00 is output.

- Inclination angle output: +/- 80 [deg]
- Euler angles output: ANG1 (roll), +/- 45 [deg]
- Euler angles output: ANG2 (pitch), +/- 180 [deg]

6.3. Registers

The host equipment can control the IMU by accessing the control registers inside the device by using the command message.

Table 6-5 Register Map

Address	Name	R/W	Save Para	Notes
0x00	MODE	rw		
0x01	ERROR	r		
0x02	DEV_NAME(Device name)	r		
0x03	VER(Version)	r		
0x04	MSC_CMD(Miscellaneous Command)	rw		
0x05	CONFIG1(Configuration1)	rw	#	
0x06	CONFIG2(Configuration2)	rw	#	
0x08	ATTI_PSET0	r	#	
0x09	ATTI_PSET	rw	#	
0x0A	ATTI_OSET	rw	#	
0x0B	SERIAL_L(SERIAL,Byte[5:0])(ASCII)	r		
0x0C	SERIAL_H(SERIAL,Byte[11:6])(ASCII)	r		
0x0D	TIME(Day, millisecond)	rw		

For information about the initial values of the control registers after internal initialization is finished, see the “Default Value” in explanation of each register.

Control registers with # mark in the “Save para” 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.

Each register has a maximum of 6 bytes. The byte order of register data that consist 2 bytes or more is little endian.

The “-” sign in the register description in Section 6.3 means “reserved”.

Write a “0” to reserved bits or read-only 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.

(*)When writing to a register where a “reserved” value is defined in the default value, always write this “reserved” value. Writing a different value can cause malfunction.

6.3.1. MODE Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x00	R/W	ADDR	MODE_CTRL	-	-	-	-	-
Default Value:	0x00	0x00	0x00	0x00	0x00	0x00	0x00	0x00

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

Byte2: MODE_CTRL

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
-	-	-	MODE_STAT	MODE_CMD				R/W (*1)

(*1) MODE_STAT is READ-ONLY

bit[4] MODE_STAT

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

- 0: Sampling mode
- 1: Configuration mode

bit[3:0] MODE_CMD

Executes commands related to the operation mode.

- 0001: Go to the sampling mode
- 0010: Go to the configuration mode
- 0011: Reset mode (No response)

6.3.2. ERROR Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x01	R/W	ADDR	ERR_FLAG	ERR1	ERR2	ERR3	-	-
Default Value:	0x00	0x01	0x00	0x00	0x00	0x00	0x00	0x00

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

ERR1, ERR2, ERR3 are set when each error is detected. At the same time, ERR_FLAG is updated according to the values of ERR1, ERR2 and ERR3. ERR1, ERR2, ERR3 are cleared only when the host reads them.

Byte2: ERR_FLAG

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
-	-	-	ATTI_OVR	G_A_OVR	EA3	EA2	EA1	R

bit[4] ATTI_OVR

- 0: No error occurred
- 1: Attitude angle overrange of 1 axis or more occurred

bit[3] G_A_OVR

- 0: No error occurred
- 1: Gyro and accelerometer overrange of 1 axis or more occurred

bit[2] EA3

- 0: No error occurred at ERR3(Byte5)
- 1: One or more errors occurred at ERR3(Byte5)

bit[1] EA2

- 0: No error occurred at ERR2(Byte4)
- 1: One or more errors occurred at ERR2(Byte4)

bit[0] EA1

- 0: No error occurred at ERR1(Byte3)
- 1: One or more errors occurred at ERR1(Byte3)

Byte3: ERR1

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
-	-	-	CRX_OVF	CTX_OVF	-	BUS_HEAVY	BUS_OFF	R

- bit[4] CRX_OVF
0: No error occurred
1: CAN Receive overflow occurred
- bit[3] CTX_OVF
0: No error occurred
1: CAN Send overflow occurred
- bit[1] BUS_HEAVY
0: No error occurred
1: CAN Bus heavy occurred
- bit[0] BUS_OFF
0: No error occurred
1: CAN Bus off occurred

Byte4: ERR2

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
SNS_ERR	-	-	-	-	NVM_W_ERR	NVM_R_ERR	-	R

- bit[7] SNS_ERR
0: No error occurred
1: Internal IMU error occurred
- bit[2] NVM_W_ERR
0: No error occurred
1: Nonvolatile memory write error occurred
- bit[1] NVM_R_ERR
0: No error occurred
1: Nonvolatile memory read error occurred

Byte5: ERR3

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
SNS_ERR	ROM_ERR	RAM_ERR	-	-	-	NVM_R_ERR	-	R

- bit[7] SNS_ERR
0: No error occurred
1: Internal IMU error occurred when executing self-test
- bit[6] ROM_ERR
0: No error occurred
1: ROM error occurred when executing self-test
- bit[5] RAM_ERR
0: No error occurred
1: RAM error occurred when executing self-test (only at startup)
- bit[1] NVM_R_ERR

0: No error occurred

1: Nonvolatile memory read error occurred when executing self-test

6.3.3. DEV_NAME Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x02	R/W	ADDR	DEV_NAME(ASCII)					
Default Value:	0x00	0x02	0x4A	0x50	0x32	0x35	0x35	0x47

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

This register is read only.

Byte7..2: DEV_NAME

The device name "G552PJ" is represented in ASCII code.

6.3.4. VER Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x03	R/W	ADDR	HARD_VER(ASCII)			SOFT_VER(ASCII)		
Default Value:	0x00	0x03	0x30	0x30	0x31	0x30	0x30	0x31

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

This register is read only.

Byte4..2: HARD_VER

The hardware version "100" is represented in ASCII code.

Byte7..5: SOFT_VER

The software version "100" is represented in ASCII code.

6.3.5. MSC_CMD Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x04	R/W	ADDR	MSC1	MSC1_ERR	-	-	-	-
Default Value:	0x00	0x04	0x00	0x00	0x00	0x00	0x00	0x00

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

Byte2: MSC1

Executes Miscellaneous commands. MSC1 returns to 00h, when a command completes.

0x01: Save parameter. Write current register-values into nonvolatile memory.

0x02: Restore default parameter. Restore register-values from the ROM default value

0x03: Self-test (excludes self-test of internal IMU)

0x04: Self-test of internal IMU (when device is in a static or stationary state)

0x05: Preset Zero of Attitude Angle (set the current attitude angle output to zero)

0x06: Preset Cancel of Attitude Angle (cancel attitude preset zero)

Byte3: MSC1_ERR (Error status for Miscellaneous Commands 1)

Shows error status for MSC1, when the command ends.

0x00: Success

0x01: Save parameter error

0x02: Restore default parameter error

0x03: Self-test error

0x04: Self-test of internal IMU error

0x05: Preset Zero of Attitude Angle error

0x06: Preset Cancel of Attitude Angle error

All commands return responses before command execution is completed. After the command is completed, MSC1 byte automatically goes to 00h. After the MSC1 byte goes back to 00h, then read MSC1_ERR byte to check the result of the previous MSC1 command.

Please ensure that power is not turned off during this operation. Please ensure that the power supply is stable during the execution of this operation (avoid brownouts, power sags or other disturbances).

The newly-restored values are not saved automatically to non-volatile memory. The host is required to send a save parameter command to make the changes permanent.

6.3.6. CONFIG1 Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x05	R/W	ADDR	CFG1_B1	CAN_ADDR	CAN_RATE	CAN_PRI	SOUT_EN	-
Default Value:	0x00	0x05	0x01	0x80	0x00	0x66	0x43	0x00

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

For AUTO_START, CAN_ADDR, CAN_RATE and CAN_PRI, save the register settings to non-volatile memory (save parameter execution) and restart (software reset execution or power off / on) in order to make settings effective after change.

If CAN_ADDR and CAN_RATE and CAN_PRI setting is changed, the subsequent response is returned based on the setting information before the change. For saving parameter execution, refer to MSC_CMD register in Chapter 6.3.5. For software reset execution, refer to MODE register in Chapter 6.3.1.

Byte2: CFG1_B1

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
-	-	-	-	-	-	-	AUTO_START	R/W

bit[0] AUTO_START

Sets enable / disable the Auto Start function.

0: disable

1: enable

When Auto Start is enabled, after power-on, the device enters sampling mode and sends sampling data automatically.

Byte3: CAN_ADDR

Sets CAN address.

0x00 - 0xFD: Configurable CAN address

Byte4: CAN_RATE

Sets CAN bit rate.

0x00: 250kbps

0x01: 500kbps

Byte5: CAN_PRI

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
-	PRI_RSP			-	PRI_SOUT			R/W

bit[6:4] PRI_RSP

Sets the priority of the "Response" message.

0x0: Priority 0 (highest priority)

0x1: Priority 1

0x2: Priority 2

0x3: Priority 3

0x4: Priority 4

0x5: Priority 5

0x6: Priority 6 (default priority)

0x7: Priority 7 (lowest priority)

bit[2:0] PRI_SOUT

Sets the priority of the "SOUT" message.

0x0: Priority 0 (highest priority)

0x1: Priority 1

0x2: Priority 2

0x3: Priority 3

0x4: Priority 4

0x5: Priority 5

0x6: Priority 6 (default priority)

0x7: Priority 7 (lowest priority)

Byte6: SOUT_EN

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
-	SOUT7_EN	-	SOUT5_EN	SOUT4_EN		SOUT2_EN	SOUT1_EN	R/W

bit[6] SOUT7_EN

Sets enable / disable of SOUT7 message output.

0: disable

1: enable

bit[4] SOUT5_EN

Sets enable / disable of SOUT5 message output.

0: disable

1: enable

bit[3] SOUT4_EN

Sets enable / disable of SOUT4 message output.

0: disable

1: enable

bit[1] SOUT2_EN

Sets enable / disable of SOUT2 message output.

0: disable

1: enable

bit[0] SOUT1_EN

Sets enable / disable of SOUT1 message output.

0: disable

1: enable

6.3.7. CONFIG2 Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x06	R/W	ADDR	-	ATTI_CTRL	ATTI_CTRL2	-	DOUT_RATE	FILTER_SEL
Default Value:	0x00	0x06	0x00	0x01	0x00	0x00	0x07	0x08

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

Byte3: ATTI_CTRL

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
BASE_ATT					-	EULER_EN	ATTI_EN	R/W

(*): When this byte is changed, registers ATTI_PSET0, ATTI_PSET and ATTI_OSET are reset.

bit[7:3] BASE_ATT

Selects the reference attitude.

0x0: attitude a

0x1: attitude b

0x2: attitude c

.

.

0x17: attitude x

※For details of the reference attitude, refer to Chapter 5.3 Reference Attitude.

bit[1] EULER_EN

Selects attitude angle output mode.

0: Inclination angle

1: Euler angle

bit[0] ATTI_EN

Activates attitude angle output.

0: Disable attitude angle output

1: Active attitude angle output

(*): This bit can be set active only when the data output rate (DOUT_RATE) is set to 200, 100, 50sps.

Byte4: ATTI_CTRL2

bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	R/W
-						ATTI_MOTION_PROFILE		R/W

bit[1:0] ATTI_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.

Select the attitude motion profile depending on the application you use.

0x0: mode A (estimated operating speed 3m/s)

0x1: mode B (estimated operating speed 20m/s)

0x2: mode C (estimated operating speed 1m/s)

Byte6: DOUT_RATE

Specifies the data output rate.

The following lists the data output rate option with the recommended number of filter taps.

0x01: 1000Sps

0x02: 500Sps

0x03: 400Sps

0x04: 250Sps

0x05: 200Sps

0x06: 125Sps

0x07: 100Sps

0x08: 80Sps

0x09: 50Sps

0x0A: 25Sps

(*): When the attitude angle output is enabled, only 200 Sps or 100Sps or 50Sps is supported.

(*): For combinations of data output rates and filter settings that can be set, refer to "Table 6-6 Valid combinations of output rate settings and filter settings". If the setting is invalid, an error will be returned in the response.

Byte7: FILTER_SEL

Specifies the type of filter and TAP setting.

0x01: Moving average filter TAP=2

0x02: Moving average filter TAP=4

0x03: Moving average filter TAP=8

0x04: Moving average filter TAP=16

0x05: Moving average filter TAP=32

0x06: Moving average filter TAP=64

0x07: Moving average filter TAP=128

0x08: FIR Kaiser filter TAP=32 and fc=50Hz

0x09: FIR Kaiser filter TAP=32 and fc=100Hz

0x0A: FIR Kaiser filter TAP=32 and fc=200Hz

0x0B: FIR Kaiser filter TAP=32 and fc=400Hz

0x0C: FIR Kaiser filter TAP=64 and fc=50Hz

0x0D: FIR Kaiser filter TAP=64 and fc=100Hz

0x0E: FIR Kaiser filter TAP=64 and fc=200Hz

0x0F: FIR Kaiser filter TAP=64 and fc=400Hz

0x10: FIR Kaiser filter TAP=128 and fc=50Hz

0x11: FIR Kaiser filter TAP=128 and fc=100Hz

0x12: FIR Kaiser filter TAP=128 and fc=200Hz

0x13: FIR Kaiser filter TAP=128 and fc=400Hz

(*): For combinations of data output rates and filter settings that can be set, refer to "Table 6-6 Valid combinations of output rate settings and filter settings". If the setting is invalid, an error will be returned in the response.

Table 6-6 Valid combinations of output rate settings and filter setting

			Ouput rate setting												
			Enable attitude angle output ATTI_EN=1			Disable attitude angle output ATTI_EN=0									
			200	100	50	1000	500	400	250	200	125	100	80	50	25
Filter Setting	Moving average filter	tap=2				✓									
		tap=4				✓	✓								
		tap=8				✓	✓	✓	✓						
		tap=16	✓			✓	✓	✓	✓	✓	✓				
		tap=32	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓		
		tap=64	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
		tap=128				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	FIR Kaiser filter	tap=32, fc=50Hz	✓	✓		✓	✓	✓	✓	✓	✓	✓			
		tap=32, fc=100Hz	✓			✓	✓	✓	✓	✓					
		tap=32, fc=200Hz				✓	✓	✓							
		tap=32, fc=400Hz				✓									
		tap=64, fc=50Hz	✓	✓		✓	✓	✓	✓	✓	✓	✓			
		tap=64, fc=100Hz	✓			✓	✓	✓	✓	✓					
		tap=64, fc=200Hz				✓	✓	✓							
		tap=64, fc=400Hz				✓									
		tap=128, fc=50Hz				✓	✓	✓	✓	✓	✓	✓			
		tap=128, fc=100Hz				✓	✓	✓	✓	✓					
		tap=128, fc=200Hz				✓	✓	✓							
		tap=128, fc=400Hz				✓									

✓ : valid combinations

6.3.8. ATTI_PSET0 Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x08	R/W	ADDR	P0_ANG1		P0_ANG2		-	
Default Value:	0x00	0x08	0x00	0x00	0x00	0x00	0x00	0x00

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

This register indicates the current attitude angle data when "attitude angle preset zero" is active.
For "Attitude angle preset zero" execution, refer to MSC_CMD register in Chapter 6.3.5.

This register is read only.

Depending on the attitude angle output mode setting (refer to 6.3.7 CONFIG2 register, EULER_EN of ATTI_CTRL byte), this register indicates either inclination angle or euler angle.

When the ATTI_CTRL register setting is changed (refer to 6.3.7 CONFIG2 register), this register is reset.

Byte3,2: P0_ANG1

Indicates the current attitude angle data 1 when "attitude angle preset zero" is active.
For the meaning of attitude angle data 1, refer to the 5.3 reference attitude.
The data format is a 16-bit two's complement representation with a scale factor of 0.01 [deg/LSB].

Byte5,4: P0_ANG2

Indicates the current attitude angle data 2 when "attitude angle preset zero" is active.
For the meaning of attitude angle data 2, refer to the 5.3 reference attitude.
The data format is a 16-bit two's complement representation with a scale factor of 0.01 [deg/LSB].

6.3.9. ATTI_PSET Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x09	R/W	ADDR	P_ANG1		P_ANG2		-	
Default Value:	0x00	0x09	0x00	0x00	0x00	0x00	0x00	0x00

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

The current attitude angle can be set to any attitude angle by writing the attitude angle preset value to this register. Writing to this register indirectly executes "attitude angle preset zero". The completion of this command is by confirming the completion of "attitude angle preset zero".

Refer to MSC_CMD register in Chapter 6.3.5 for the confirmation method of termination.

This register is valid only when attitude angle output is enabled (6.3.7 CONFIG2 register, ATTI_CTRL=1).

Depending on the attitude angle output mode setting (refer to 6.3.7 CONFIG2 register, EULER_EN of ATTI_CTRL byte), this register indicates either inclination angle or euler angle.

When the ATTI_CTRL register setting is changed (refer to 6.3.7 CONFIG2 register), this register is reset.

Byte3,2: P_ANG1

Set attitude angle data1 preset value.
For the meaning of attitude angle data1, refer to the 5.3 reference attitude.
The data format is a 16-bit two's complement representation with a scale factor of 0.01 [deg/LSB].

Byte5,4: P_ANG2

Set attitude angle data2 preset value.

For the meaning of attitude angle data2, refer to the 5.3 reference attitude.

The data format is a 16-bit two's complement representation with a scale factor of 0.01 [deg/LSB].

6.3.10. ATTI_OSET Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x0A	R/W	ADDR	O_ANG1		O_ANG2		-	
Default Value:	0x00	0x0A	0x00	0x00	0x00	0x00	0x00	0x00

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

Writing the attitude angle offset value to this register will apply this offset angle to the current attitude angle output.

This register is valid only when attitude angle output is enabled (6.3.7 CONFIG2 register, ATTI_CTRL=1).

Depending on the attitude angle output mode setting (refer to 6.3.7 CONFIG2 register, EULER_EN of ATTI_CTRL byte), this register affects either inclination angle or euler angle.

When the ATTI_CTRL register setting is changed (refer to 6.3.7 CONFIG2 register), this register is reset.

Byte3,2: O_ANG1

Set attitude angle data1 offset value.

For the meaning of attitude angle data1, refer to the 5.3 reference attitude.

The data format is a 16-bit two's complement representation with a scale factor of 0.01 [deg/LSB].

Byte5,4: O_ANG2

Set attitude angle data2 offset value.

For the meaning of attitude angle data2, refer to the 5.3 reference attitude.

The data format is a 16-bit two's complement representation with a scale factor of 0.01 [deg/LSB].

6.3.11. SERIAL_L Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x0B	R/W	ADDR	SERIAL_L(ASCII)					
Default Value:	0x00	0x0B	0x38	0x37	0x36	0x35	0x34	0x33

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

This register is read only.

Byte7..2: SERIAL_L

Displays the lower 6 bytes of the serial number in ASCII notation.

As an example, put the value of serial number 12345678 in Default Value.

6.3.12. SERIAL_H Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x0C	R/W	ADDR	SERIAL_H(ASCII)					
Default Value:	0x00	0x0C	0x32	0x31	0x30	0x30	0x30	0x30

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

This register is read only.

Byte7..2: SERIAL_H

Displays the upper 6 bytes of the serial number in ASCII notation.

As an example, put the value of serial number 12345678 in Default Value.

6.3.13. TIME Register

Address	Byte0	Byte1	Byte2	Byte3	Byte4	Byte5	Byte6	Byte7
0x0D	R/W	ADDR	MS				DAY	
Default Value:	0x00	0x0D	0x00	0x00	0x00	0x00	0x00	0x00

For the meaning of R/W and ADDR, refer to Chapter 6.2.2 Command Message.

By writing to this register, the internal time of this device can be set to any value.

The internal time of this device can be acquired by reading this register.

Byte5..2: MS

Displays the millisecond (resolution is $1/16\text{ms} = 62.5\mu\text{s}$ unit) of the internal time of this device.
Cannot set a value greater than 0x5265C000.

Byte7..6: DAY

Displays the day of the internal time of this device.

6.4. Error Code

Indicates the error code that goes into the STS byte of Response Message (PGN 65504).

Table 6-7 Error code (@Read request)

STS	Symbol	Description
01h	ERR_BUSY	Command cannot be executed because the command is being executed or the mode is being changed.
02h	ERR_RW_PARAM_INVALID	R / W (Byte0) of Command message is other than 0x00 and 0x80.
03h	ERR_REG_ADDR_INVALID	ADDR (Byte1) of Command message is out of valid range.
04h	ERR_ACCESS_NOT_ALLOWED	In the Command message, read to a read-protected register or write to a write-protected register.
0Ah	ERR_MSG_LENGTH_INVALID	The message byte length of the Command message is not 8 bytes.

Table 6-8 Error code (@Write request)

STS	Symbol	Description
81h	ERR_BUSY	The command cannot be executed because the command is being executed or the mode is being changed.
83h	ERR_REG_ADDR_INVALID	ADDR (Byte1) of Command message is out of valid range.
84h	ERR_ACCESS_NOT_ALLOWED	In the Command message, read to a read-protected register or write to a write-protected register.
85h	ERR_SENSOR_ACCESS	Read / write error to built-in sensor (IMU).
86h	ERR_CANNOT_IN_THIS_STATE	The command cannot be executed due to a certain internal state.
89h	ERR_CANNOT_IN_THIS_SETTING	The command cannot be executed due to inconsistent settings.
8Ah	ERR_MSG_LENGTH_INVALID	The message byte length of the Command message is not 8 bytes.
92h	ERR_MSG_BYTE2_INVALID	Byte2 of Command message is invalid
93h	ERR_MSG_BYTE3_INVALID	Byte3 of Command message is invalid
94h	ERR_MSG_BYTE4_INVALID	Byte4 of Command message is invalid
95h	ERR_MSG_BYTE5_INVALID	Byte5 of Command message is invalid
96h	ERR_MSG_BYTE6_INVALID	Byte6 of Command message is invalid
97h	ERR_MSG_BYTE7_INVALID	Byte7 of Command message is invalid

98h	ERR_MSG_BYTE23_INVALID	Byte2 and 3 of Command message are invalid
99h	ERR_MSG_BYTE45_INVALID	Byte4 and 5 of Command message are invalid
9Ah	ERR_MSG_BYTE67_INVALID	Byte6 and 7 of Command message are invalid
9Bh	ERR_MSG_BYTE2345_INVALID	Byte2,3,4 and 5 of Command message are invalid

6.5. LED Indicator

6.5.1. Red LED

The red LED indicates the CAN bus status. The details are shown in the table below.

Table 6-9 Red LED specifications

Bus status	Occurrence condition		Red LED
	CAN transmission error counter (TEC)	CAN Receive error counter (REC)	
Normal	$0 \leq \text{TEC} < 96$	and $0 \leq \text{REC} < 96$	off
Bus Heavy	$96 \leq \text{TEC} < 256$	or $96 \leq \text{REC} < 256$	single flash (On for 200ms, Off for 1s)
Bus off	$256 \leq \text{TEC}$	—	on

6.5.2. Green LED

The green LED indicates the operating state of this device. The details are shown in the table below.

Table 6-10 Green LED specifications

Operating state	Description	Green LED
INITIAL	During the internal initialization	off
NOT_READY	Bad startup or built-in IMU error	single flash (On for 200ms, Off for 1s)
CONFIG	During the Configuration mode	blinking (On for 200ms, Off for 200ms)
SAMPLING	During the Sampling mode	on

7. PART NUMBER / ORDERING INFO

The following is the ordering code for the product:

Product Type	Product Name	Product code
IMU for CAN Interface (J1939 Protocol)	M-G552PJ10	X2G000121000100

8. Handling Notes

8.1. 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 must not be used in the application and/or 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, rail vehicles, personal cars, etc.). Therefore, Seiko Epson Corporation will not be liable for any and all damages caused by using this product for those applications and/or equipment.
- Do not alter or disassemble the product.

8.2. 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.

8.3. 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 CAN standard.
- Please do the wiring work with the power of the equipment turned off.

9. STANDARDS AND APPROVALS

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

9.1. 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.

9.2. 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

9.3. 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

9.4. 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
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Hempstead, Hertfordshire, HP3 9TD,
United Kingdom

9.5. 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.

9.6. Industry ICES Compliance Statement for Canadian users

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

10. Revision History

Attachment-1

Rev. No.	Date	Page	Category	Contents
Rev.1.0	Apr. 2021	All	New	New
Rev. 1.1	Jul. 2021	1,5	Modify	unit change of Gyro Characteristics °/s → °/h
Rev. 1.2	Apr. 2022	40	Modify	Product Number Change
Rev.1.3	Dec. 2022	42	Modify	UKCA compliance and regulatory amendments
Rev.1.4	Jul. 2023	cover	Modify	Corporate logo change
Rev.1.5	Sep. 2023	1	Modify	1 Overview Correction of typos (Attitude angle function is not implemented)

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Rev.1.5