Distributed by:

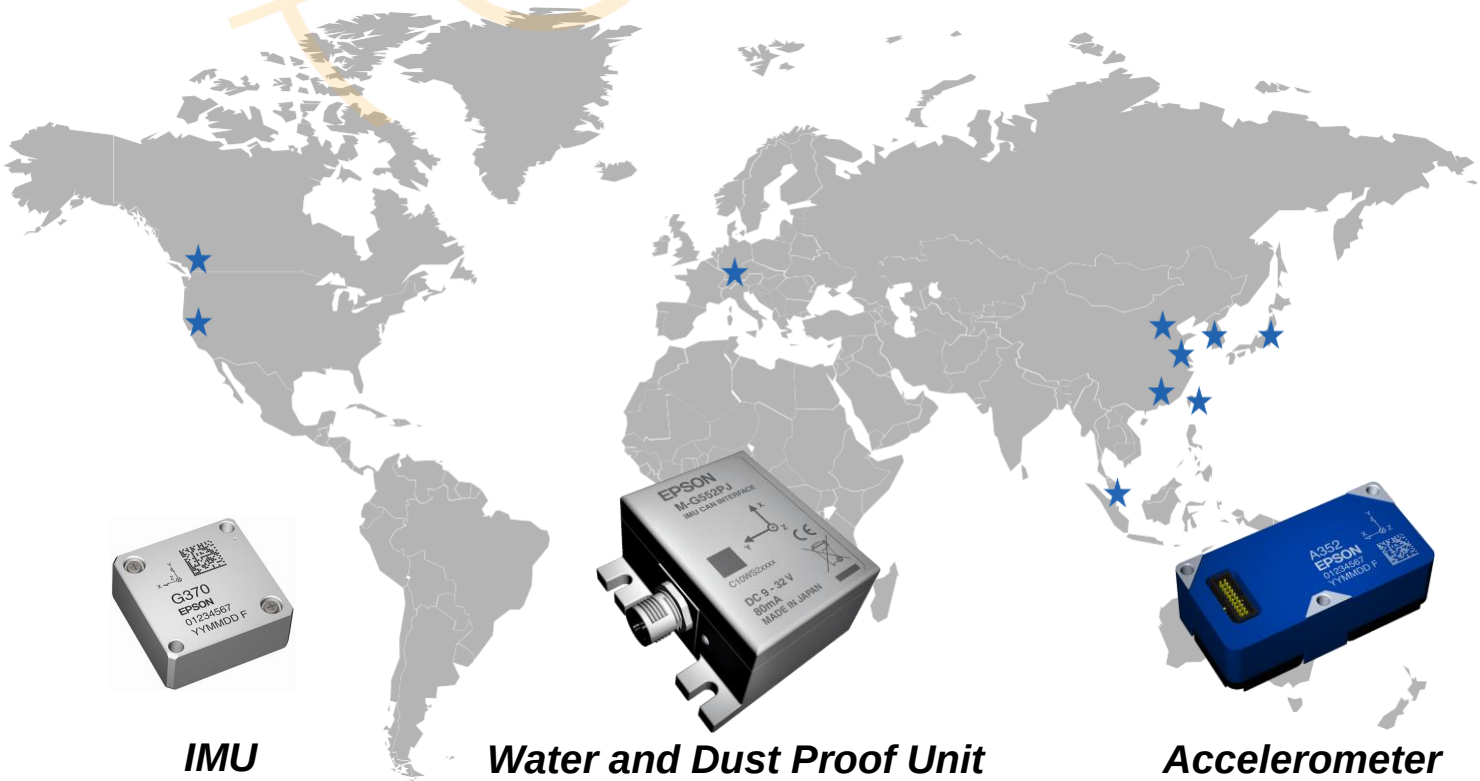
TEXIM EUROPE

www.texim-europe.com

EPSON

EXCEED YOUR VISION

High Performance Gyro Sensors, IMUs and Accelerometers



IMU ***Water and Dust Proof Unit*** ***Accelerometer***

Distributed by www.texim-europe.com

NOTICE

No part of this material may be reproduced or duplicated in any form or by any means without the written permission of Seiko Epson. Seiko Epson reserves the right to make changes to this material without notice. Seiko Epson does not assume any liability of any kind arising out of any inaccuracies contained in this material or due to its application or use in any product or circuit. 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. Moreover, no license to any intellectual property rights is granted by implication or otherwise, and there is no representation or warranty that anything made in accordance with this material will be free from any patent or copyright infringement of a third party. When exporting the products or technology described in this material, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You are requested not to use, to resell, to export and/or to otherwise dispose of the products (and any technical information furnished, if any) for the development and/or manufacture of weapon of mass destruction or for other military purposes.

All brands or product names mentioned herein are trademarks and/or registered trademarks of their respective companies

Index

■ Contribute to Society with High Precision Sensing Technology

Using our core sensor technology, we provide innovative solutions to manage the social infrastructure (labor saving / efficiency improvement, machine maintenance, deterioration diagnosis). With this high precision sensing technology, we deliver practical applications in extremely challenging environments to provide society with convenience, security, and safety. We continually strive to create highly innovative industrial sensor products.

i. Automation :Implement automation/autonomy for numerous applications with precise motion detection and control.

ii. Comfort, Safety :Implement preventive maintenance of Infrastructure/Machinery by advanced knowledge in detecting a change in operating conditions.

■ Crystal Processing Technology to Realize High Precision Sensing Technology

We have developed high-performance quartz crystal sensor elements that use Epson's proprietary microfabrication technology featuring high stability, low consumption, and low noise to create high-precision IMU and acceleration sensors

■ Characteristics of Quartz Crystal Vibration Sensing

○ **Material : Quartz Crystal**

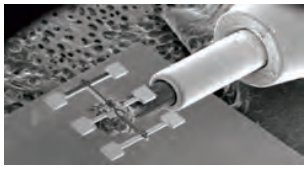
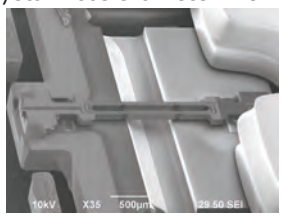
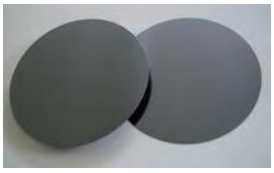
- High Q-factor and stable elasticity against temperature changes, so it achieves performance that is resistant to external disturbances
- Quartz crystal is a piezoelectric material, so even small Coriolis force is converted to an electrical signal by piezoelectric effect to deliver high sensitivity and excellent noise performance.

○ **Sensing Method - Gyro Sensor : Double-T Element Structure**

- Unique isolation of the drive and detection system reduces vibration leakage to achieve high signal-noise ratio
- Excellent symmetry of element structure provides high resilience against external vibration and shock

○ **Sensing Method - Accelerometer : Double-Ended Tuning Fork with Frequency Change Detection**

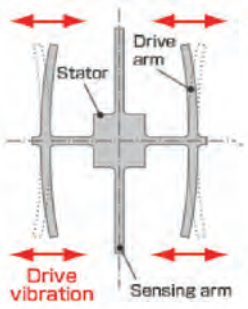
- Extremely wide dynamic range by exploiting large mass and displacement properties
- Low noise and low power readily achieved by high sensitivity double-ended tuning fork vibrator

<table>
<tr><th></th><th>Material</th><th>Element Structure</th></tr>
<tr><td rowspan="2">Quartz Crystal Sensor Element
(Epson)</td><td rowspan="2">Synthetic Crystal
  </td><td>Crystal Gyro Sensor Element
 
Double-T element type</td></tr>
<tr><td>Crystal Accelerometer Element
 
Double-ended tuning fork type</td></tr>
<tr><td>Silicon Sensor Element</td><td>Silicon
  </td><td>Si MEMS
NOTE: Every company uses a different structure</td></tr>
</table>

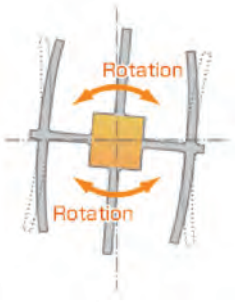
■ Principle of Angular Velocity Detection by Quartz Gyro Sensor

How Angular Velocity Sensing Works (in Vibration Gyro Sensors)

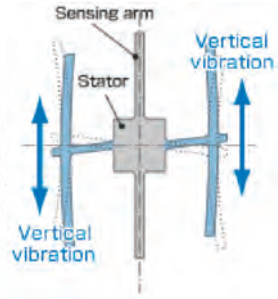
Vibration gyro sensors sense angular velocity from the Coriolis force applied to a vibrating object.
Here, we explain how this works, using as an example Epson 's double-T structure quartz crystal element.



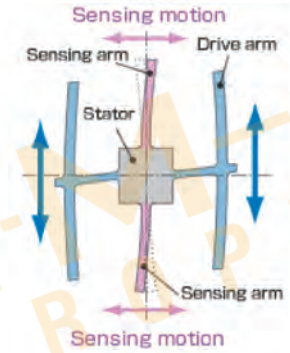
1. Normally, drive arms vibrate in a certain direction.



2. Direction of rotation



3. When the gyro is rotated, the Coriolis force acts on the drive arms, producing vertical vibration.



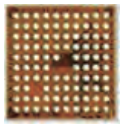
4. The stationary part bends due to vertical drive arm vibration, producing a sensing motion in the sensing arms.

5. The motion of a pair of sensing arms produces a potential difference from which angular velocity is sensed. The angular velocity is converted to, and output as, an electrical signal.

■ Low Power Dedicated SoC

EPSON's IMUs utilize dedicated SoC (System-on-Chip) to reduce power 50% and integrate 50% of the peripheral discrete components compared to our previous generation IMUs such as M-G350.

M-G365/370 Power Consumption: 16 mA (Typ.) @ 3.3 V (53 mW)
M-A352 Power Consumption: 13 mA (Typ.) @ 3.3 V (43 mW)



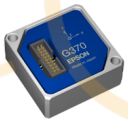
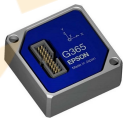
SoC

■ Approach for Quality improvement

We have acquired ISO 9001 certification to provide high quality, high reliability products and services that meet the needs of our customers.

■ Sensor Product Line-up

Target Application	Gyro Sensor	
	Z-Axis	Others
Automotive Safety	 XV-9100CD DR: ± 100 °/s  XV-9100LV DR: ± 100 °/s	 XV-9300LP DR: ± 300 °/s (90 °)
Automotive	 XV4001Bx ZRLt: ± 3 °/s	 XV4001Kx ZRLt: ± 3 °/s (20 °)
Consumer / Industrial	 XV7021BB ZRLt: ± 0.3°/s BIS: 2.8 °/h  XV7011BB ZRLt: ± 1 °/s BIS: 3.8 °/h  XV7001BB ZRLt: ± 5 °/s BIS: 3.8 °/h	-

Target Application	IMU	
	Built-in Type	Water and Dust Proof Type
Industrial	 M-G370 DR Gyro :± 450 °/s DR Accl : ±10 G Gyro BIS : 0.8 °/h  M-G365 DR Gyro :± 450 °/s DR Accl : ±10 G/± 4 G Gyro BIS : 1. 2 °/h	 M-G552 Series DR Gyro: ± 450°/s DR Accl: ± 10 G J1939/CANopen/RS422

Target Application	Accelerometer	
	Built-in Type	Water and Dust Proof Type
Industrial	 M-A352 DR: ± 15G Acceleration/Shock:1,000G	 M-A552 DR: ± 15G Acceleration/Shock : 1,000G CANopen / RS422

■ Gyro Sensor

Automotive

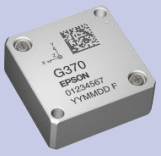
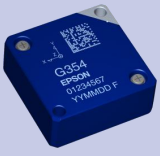
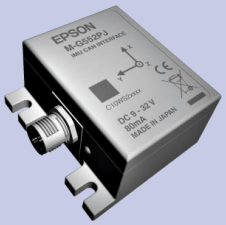
Model	External Dimensions (mm)	Supply Voltage (V)	Bias	Rate Range (° /s)	Scale Factor	Non Linearity (%FS)	Operating Temperature	Recommended Application
XV-9100CD	 5.0 × 5.0 × 1.4	4.75 ～ 5.25	0.5 × VDD V	± 100	0.004 × VDD mV/(° /s)	± 0.5	-40 ° C ～ +105 ° C	Electric Stability Control Rollover Protection System
XV-9300CD				± 300	0.0012 × VDD mV/(° /s)			
XV-9100LV	 7.0 × 6.8 × 3.3			± 100	0.004 × VDD mV/(° /s)		-40 ° C ～ +125 ° C	
XV-9300LV				± 300	0.0012 × VDD mV/(° /s)			
XV-9100LP	 9.5 × 5.0 × 7.2			± 100	0.004 × VDD mV/(° /s)			
XV-9300LP				± 300	0.0012 × VDD mV/(° /s)			
XV4001KC (I^2C-Bus) XV4001KD (SPI-Bus)	 6.0 × 4.8 × 3.3	3.0 ～ 3.6	0 LSB Typ. ± 2 ° /s	± 70	16bit : 370 LSB/ (° /s)	± 0.5	-40 ° C ～ +85 ° C	Car Navigation System
XV4001BC (I^2C-Bus) XV4001BD (SPI-Bus)	 5.0 × 3.2 × 1.3							

Consumer / Industrial

Model	External Dimensions (mm)	Supply Voltage (V)	Bias	Rate Range (° /s)	Scale Factor	Non Linearity (%FS)	Operating Temperature	Recommended Application
XV7021BB (SPI / I^2C)	 5.0 × 3.2 × 1.3	2.7 ～ 3.6	0 LSB Typ. ± 1 ° /s	± 400	24bit : 17,920 LSB/(° /s)	± 0.5	-20 ° C ～ +80 ° C (-40 ° C ～ +85 ° C Please contact us)	Anti Vibration and Attitude Control for Industrial Applications etc.
XV7011BB (SPI / I^2C)				± 100	24bit : 71,680 LSB/(° /s)			
XV7001BB (SPI / I^2C)			0 LSB Typ. ± 5 ° /s	± 100	16bit : 280 LSB/(° /s)		-20 ° C ～ +80 ° C	Motion Detection for Man Machine Interface
XV-3510CB	 5.0 × 3.2 × 1.3	2.7 ～ 3.3	1430 mV	± 300	3.0 mV/(° /s)	± 0.5	-20 ° C ～ +80 ° C	Detection Picture Stabilization

■ IMU Product Line-up

- M-G370 : Top Model IMU
- M-G365 : Standard IMU
- M-G364 : High Stability IMU
- M-G354 : Wide Dynamic Range IMU
- M-G552 Series : Water and Dust Proof IMU with J1939, CANopen and RS422 Interface (Interface is selectable)

			M-G370	M-G365	M-G364	M-G354	New M-G552 Series*
Features			Top Model	Built in EKF	High Stability	Wide Range	Water and Dust Proof
Gyroscope	Bias Instability	°/h	0.8	1.2	2.2	3	1.2
	Dynamic Range	°/s	± 450		± 200	± 450	± 450
	Angular Random Walk	°/√h	0.06	0.08	0.09	0.1	0.08
	Bandwidth	Hz (Max.)	189	472	200	200	472
Accelero meter	Dynamic Range	G	± 10	± 4 / ± 10	± 3	± 5	±10
	Initial Bias	mG, σ	2	3	5	5	4
Misalignment (Gyro/Accelerometer)		°	0.01		0.02/0.01		0.01
Current Consumption		mA (Typ.)	16		18		32 @12 V
Voltage Supply		V	3.3				9 ～ 30
Operating Temperature		℃	-40 ～ +85				- 30 ～ + 80
Interface			SPI/UART				J1939 (CANopen and RS422 is selected by order code)
Size		mm³	24 x 24 x 10				65 x 60 x 30
Weight		g	10				115
Dynamic Tilt Function EKF (Extended Kalman Filter)			---	Buit in	---		Buit in
Fuctions			External Trigger Input, etc				IP67
Product Image							

* The product model number and specification values are determined by the built-in IMU.
The values on this page are the specifications of M-G552PJ1. Please contact us for detailed information on other products.
Interface is selected by order code.

■ Accelerometer Product Line-up

- M-A352AD1 : Built-in Type, High Shock Resistance (UART / SPI Interface)
- M-A552AC1/AR1 : Water and Dust Proof, High Shock Resistance(CAN / RS422 Interface)

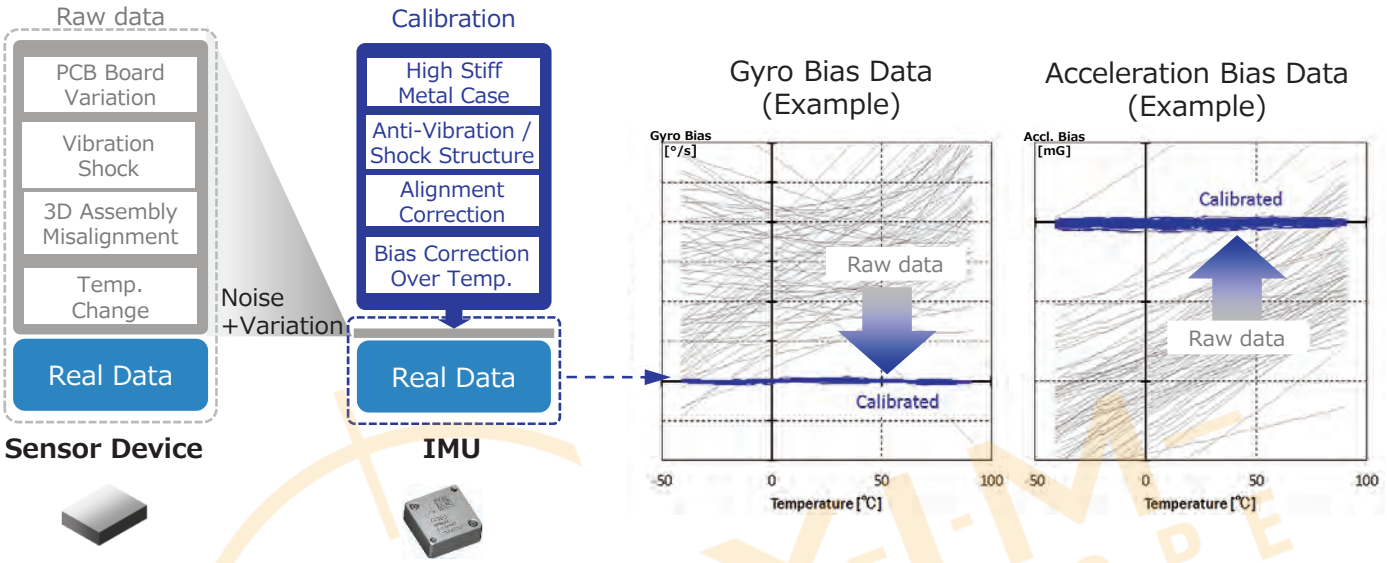
		M-A352AD1	M-A552AC1 / M-A552AR1	
Features		Built-in Type, High Shock Resistance	Water and Dust Proof (IP67) High Shock Resistance	
Interface		UART / SPI Selectable	M-A552AC1 CANopen	M-A552AR1 RS422
Noise Density	μG/√Hz	0.2	0.5	
Input Range	G	± 15	± 15	
Axis		3Axis (X/Y/Z)	3Axis (X/Y/Z)	
Bandwidth	Hz(Max.)	460	460	
Output Rate	Sps (Max.)	1,000	1,000	
Resolution	μG/LSB	0.06	0.06	
Operating Temperature	℃	-30 ～ +85	-30 ～ +70	
Current Consumption	mA(Typ.)	13.2	35@12 V	49 @12 V
Shock (max)	G	1,000	1,000	
Voltage Supply	V	3.3	9 ～ 32	
Size	mm^3	50 x 24 x 16	65 x 60 x 30	
Weight	grams	25	128	
Output Mode		Acceleration, Tilt Angle (Selectable on each axis)	Acceleration, Tilt Angle (Selectable on each axis)	
Product Image				

■ IMU (Inertial Measurement Unit)

A device which detects the inertial motion with high accuracy, composed of 3 axis GYROSCOPE and 3 axis ACCELEROMETER. IMUs are mainly used for the purpose of measuring and controlling the motion or attitude of a moving body.

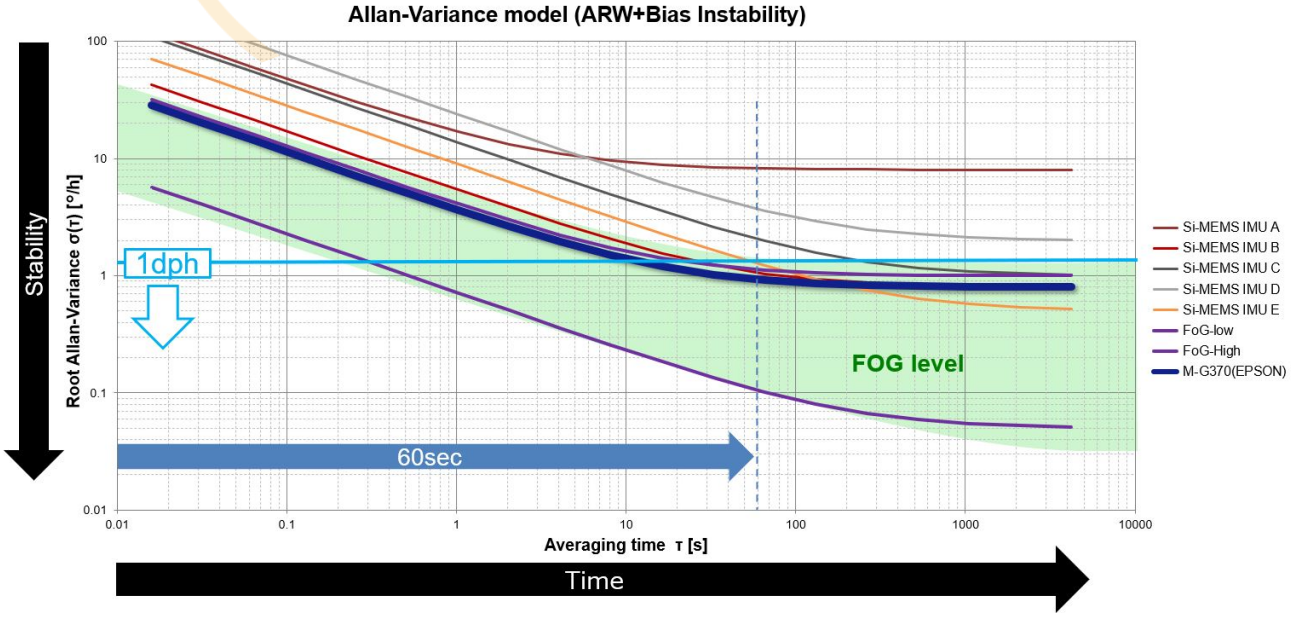
■ IMU and Sensor Device

In actual operating environments, the accuracy of sensor device output data deteriorates because of various external and internal influences (board variation, vibration & shock, misalignment, temperature change etc.). However, the IMU has various correction functions to reduce errors and output stable and accurate sensing data.



■ Crystal Sensing Technology

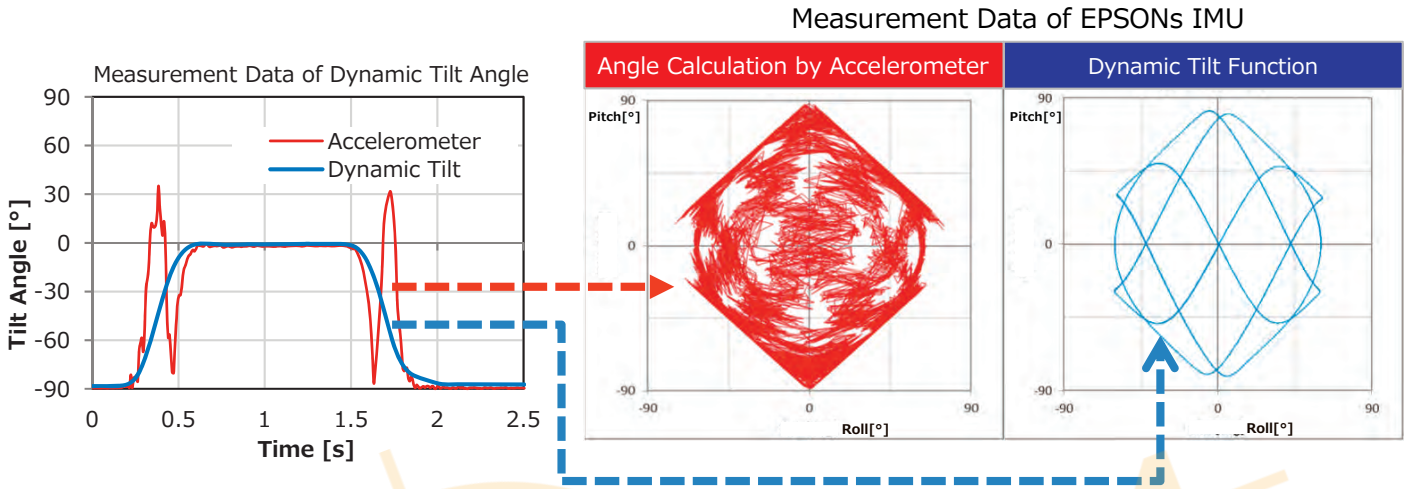
By using crystal sensor element based on Epson's proprietary micro-fabrication technology, we realized compact, highly accurate, and highly stable IMUs / accelerometer by making use of the exceptional properties of crystal material (high stability and low noise). In addition, by using superior processing technology to achieve high performance with low variation, we overcome the challenge of accuracy variability, and stable supply of final products.



Dynamic Characteristics

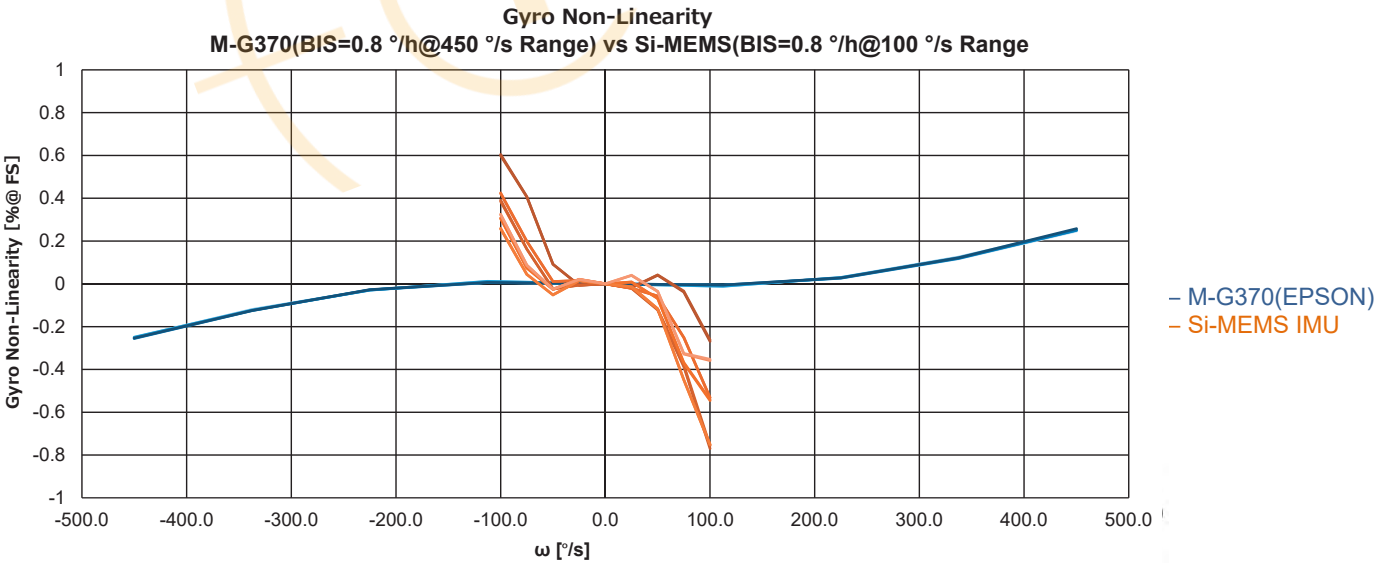
■ Dynamic Tilt Function - Attitude Angle Output -

The built-in Extended Kalman Filter (EKF) and dynamic tilt output function sends dynamic attitude angle data in real time to reduce the processing load of the main CPU and reduce the amount of sensor data communication. In addition, since the signal processing inside IMU is in real time, the same low current consumption is achieved as our conventional products. This high-performance IMU is especially suitable for applications that measure and control the attitude during motion.



■ Linearity Characteristics

The superior bias instability (0.8 °/h) and linearity (0.5 %) performance is achieved with a wide dynamic range (450 °/s). These IMUs can be employed in a wide range of applications to measure a diverse category of motion dynamics with high precision for both slow and fast operation.



TOP Model IMU (ARW:0.06 °/√h , BIS:0.8 °/h)

■ GENERAL DESCRIPTION

The M-G370 is a small form factor inertial measurement unit (IMU) with 6 degrees of freedom: triaxial angular rates and linear accelerations, and provides high-stability and high-precision measurement capabilities with the use of high-precision compensation technology. A variety of calibration parameters are stored in memory of the IMU, and are automatically reflected in the measurement data being sent to the application after the power of the IMU is turned on.
M-G370 is top-of-the-line IMU provides FOG-class performance in a 1-inch package.

■ FEATURES

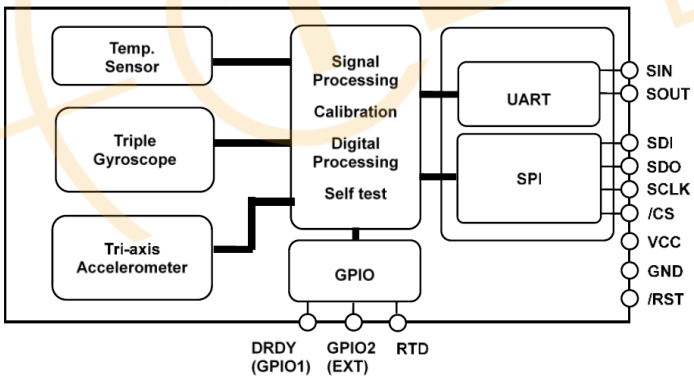
Sensor Spec.	: Gyroscope	Accelerometer
Dynamic Range	: ± 450 °/s	± 10 G
Bias instability	: 0.8 °/h	10 µG
Random Walk	: 0.06 °/√h	0.025 (m/s)/√h
Initial Bias Error	: 360 °/h (1 σ)	2 mG

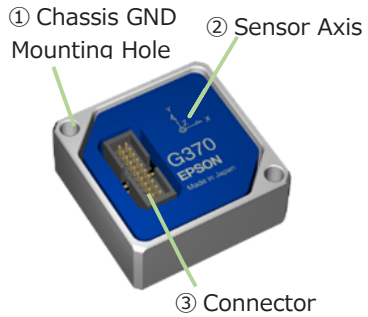
Output Interface	: SPI / UART
Data Output Rate	: ~ 2,000 Sps
Temperature Range	: – 40℃ ~ +85 ℃ (Operating and Calibration)
Power Supply Voltage	: 3.3 V, Current Consumption : 16 mA(Typ.)
Size・Weight	: 24 x 24 x 10 mm³, 10 g
Functions	: Run Time Diagnostics
	: Delta Angle / Delta Velocity Output
	: External Trigger Input, External Counter Reset Input

■ APPLICATIONS

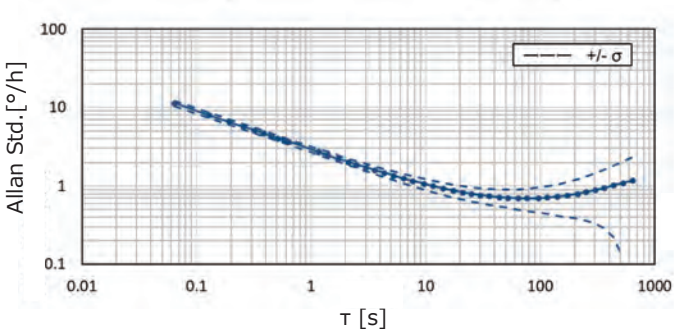
Antenna Platform Stabilization, Camera Gimbals, Navigation Systems, Vibration Control and Stabilization, Pointing and Tracking Systems, Autonomous Vehicle

■ FUNCTIONAL BLOCK DIAGRAM





■ PERFORMANCE CHARACTERISTICS (Gyroscope Allan Variance)



Top Model IMU (ARW:0.06 °/√h , BIS:0.8 °/h)

■ SENSOR SPECIFICATION

T_A=25° C, VCC=3.3 V, angular rate=0 °/s, ≤± 1 G, unless otherwise noted.

Parameter	Test Conditions / Comments	Min.	Typ.	Max.	Unit
GYRO SENSOR					
Sensitivity					
Dynamic Range	-	-	± 450	-	°/s
Scale Factor	16 bit, when 32 bit, × 2^16	-0.2 %	66	+0.2 %	LSB/(°/s)
Nonlinearity (Best fit straight line)	1 σ , <300 °/s *3	-	0.05	-	% of FS
	1 σ , >300 °/s *3	-	0.2	-	
Misalignment	1 σ , Axis-to-axis, Δ = 90 ° ideal	-	0.01	-	°
Bias					
Initial Error	1 σ , – 40 ° C ≤ T_A ≤ +85 ° C	-	360	-	°/h
Repeatability	1 σ , turn-on to turn-on	-	36	-	°/h
Bias Instability	Average		0.8		°/h
Angular Random Walk	Average	-	0.06	-	°/√h
Linear Acceleration Effect	Average		18		(°/h)/G
Noise Density	Average , f = 10 Hz to 20 Hz	-	4.68	-	(°/h)/√Hz
Frequency Property					
-3 dB Bandwidth	-	-	189	-	Hz (Max.)
ACCELEROMETERS					
Sensitivity					
Dynamic Range		-	± 10	-	G
Scale Factor	16 bit, when 32 bit, × 2^16	-0.1%	0.4	+0.1%	mG/LSB
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 , – 40 ° C ≤ T_A ≤ +85 ° C	-	2	-	mG
Repeatability	1 σ , turn-on to turn-on *3	-	2	-	mG
Bias Instability	Average	-	12	-	μG
Velocity Random Walk	Average	-	0.025	-	(m/s)/√hr
Noise Density	Average, f=10 Hz to 20 Hz	-	60	-	μG/√Hz
Frequency Property					
3 dB Bandwidth	-	-	167	-	Hz(Max.)
TEMPERATURE SENSOR					
Scale Factor *1 *2	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.
Note) The values in the specifications are based on the data calibrated at the factory. The values may change according to the way the product is used.
Note) The Typ values in the specifications are average values or 1 σ values.
Note) Unless otherwise noted, the Max / Min values in the specifications are design values or Max / Min values at the factory tests.

Latest Generation Standard IMU (1.2 °/h)

■ GENERAL DESCRIPTION

The M-G365 is a small form factor inertial measurement unit (IMU) with 6 degrees of freedom: triaxial angular rates and linear accelerations, and provides high-stability and high-precision measurement capabilities with the use of high-precision compensation technology. A variety of calibration parameters are stored in memory of the IMU, and are automatically reflected in the measurement data being sent to the application after the power of the IMU is turned on.
The M-G365 has a new attitude angle output function and supports a wide variety of applications.
An original high-speed DSP with an extended Kalman filter provides highly accurate real-time attitude angle output at low power consumption.

■ FEATURES

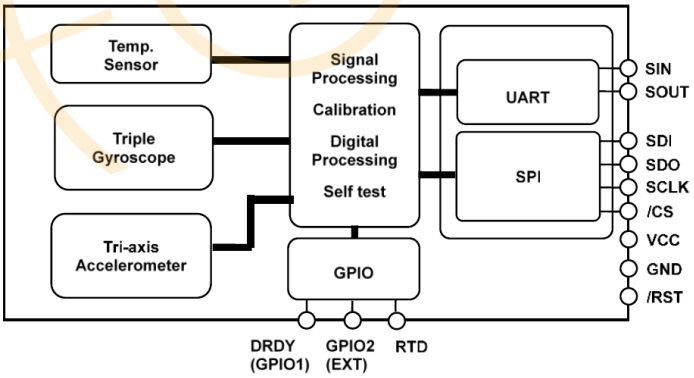
Sensor Spec.	: Gyroscope	Accelerometer
Dynamic Range	: ± 450 °/s	± 4 G or ± 10 G (*selectable)
Bias instability	: 1.2 °/h	14 µG or 16 µG
Random Walk	: 0.08 °/√h	0.02 (m/s)/√h or 0.033 (m/s)/√h
Initial Bias Error	: 360 °/h (1 σ)	3 mG

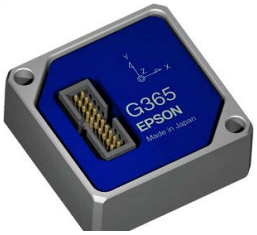
Output Interface	: SPI / UART
Data Output Rate	: ~ 2,000 Sps
Temperature Range	: – 40℃ ~ +85 ℃ (Operating and Calibration)
Power Supply Voltage	: 3.3 V, Current Consumption : 16 mA(Typ.)
Size・Weight	: 24 x 24 x 10mm^3, 10g
Functions	: Dynamic Tilt Function
	: External Trigger input, External Counter Reset input
	: Delta Angle / Delta velocity output

■ APPLICATIONS

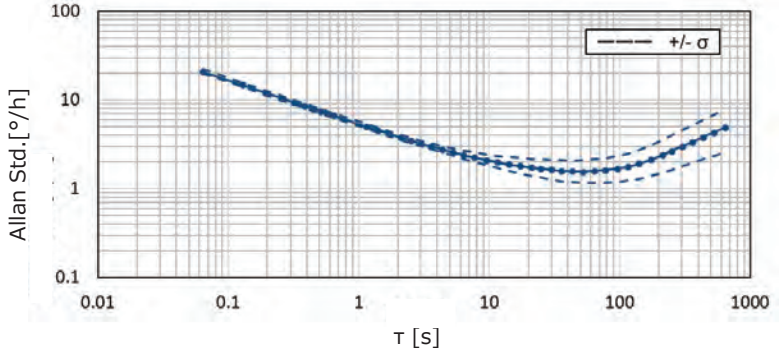
Antenna Platform Stabilization, Camera Gimbals, Navigation Systems, Vibration Control and Stabilization, Pointing and Tracking Systems, Autonomous Vehicle

■ FUNCTIONAL BLOCK DIAGRAM





■ PERFORMANCE CHARACTERISTICS (Gyroscope Allan Variance)



Latest Generation Standard IMU (1.2 °/h)

■ SENSOR SPECIFICATION

T_A=25° C, VCC=3.3 V, angular rate=0 °/s, ≤± 1G, unless otherwise noted.

Parameter	Test Conditions / Comments	Min.	Typ.	Max.	Unit
GYRO sensor					
Sensitivity					
Dynamic Range	-	-	± 450	-	°/s
Scale Factor	16bit, when 32bit, × 2^16	-0.2%	66	+0.2%	LSB/(°/s)
Nonlinearity (Best fit straight line)	1 σ , <300 °/s	-	0.05	-	% of FS
	1 σ , >300 °/s	-	0.2	-	
Misalignment	1 σ , Axis-to-axis, Δ = 90 ° ideal	-	0.01	-	°
Bias					
Initial Error	1 σ , – 40 ° C ≤ T_A ≤ +85 ° 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	-	°/$\sqrt{h}$
Linear Acceleration Effect	Average		18		(°/h)/G
Noise Density	Average , f = 10 Hz to 20 Hz	-	7.2	-	(°/h)/$\sqrt{Hz}$
Frequency Property					
3 dB Bandwidth	-	-	472	-	Hz(Max.)
ACCELEROMETERS					
Sensitivity					
Dynamic Range	PDC PDF	- -	± 4 ± 10	-	G
Scale Factor	PDC : 16bit, when 32bit, × 2^16 PDF : 16bit, when 32bit, × 2^16	-0.1% -0.1%	6.25 2.5	+0.1% +0.1%	LSB/mG
Nonlinearity (Best fit straight line)	PDC :1 σ, <2 G PDF :1 σ, <5 G	-	0.1	-	% of FS
Misalignment	1 σ , Axis-to-axis, Δ = 90 ° ideal	-	0.01	-	°
Bias					
Initial Error	1 σ , – 40 ° C ≤ T_A ≤ +85 ° C	-	3	-	mG
Repeatability	1 σ , turn-on to turn-on [*3]	-	3	-	mG
Bias Instability	PDC :Average PDF :Average	- -	14 16	- -	μG
Velocity Random Walk	PDC :Average PDF :Average	- -	0.02 0.033	- -	(m/s)/$\sqrt{hr}$
Noise Density	PDC :f = 10 Hz to 20 Hz PDF :f = 10 Hz to 20 Hz	- -	48 80	- -	μG/ $\sqrt{Hz}$
Frequency Property					
-3 dB Bandwidth	-	-	167	-	Hz(Max.)
ATTITUDE OUTPUT					
Dynamic Range	Inclination Mode	-80	-	+80	°
	Euler Mode ANG1:Roll ANG2:Pitch ANG3:Yaw [*4]	-45 -180 -180	- - -	+45 +180 +180	
Scale Factor	16 bit	-	0.00012207	-	rad/LSB
		-	0.00699411	-	°/LSB
Accuracy	1 σ , Static [*4]	-	0.2	-	°
	1 σ , Dynamic [*4*5] (100 °/s, Max.)	-	0.2	-	
TEMPERATURE SENSOR					
Scale Factor [*1 *2]	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.
Note) The values in the specifications are based on the data calibrated at the factory. The values may change according to the way the product is used.
Note) The Typ values in the specifications are average values or 1 σ values.
Note) Unless otherwise noted, the Max / Min values in the specifications are design values or Max / Min values at the factory tests.

IMU M-G364

High Stability IMU

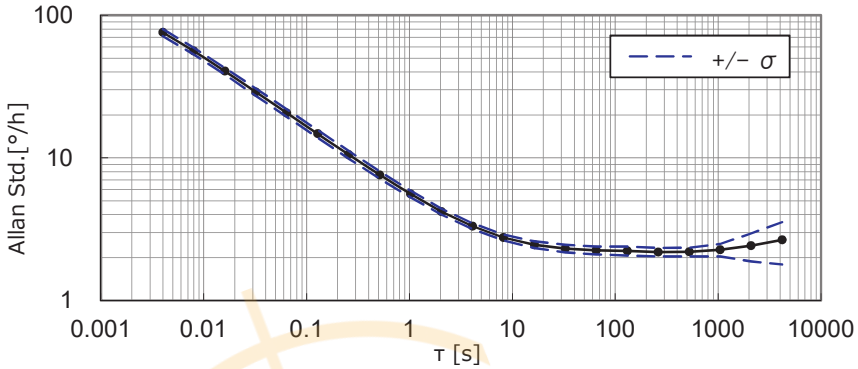
■ GENERAL DESCRIPTION

The M-G364 is a small form factor inertial measurement unit (IMU) with 6 degrees of freedom: triaxial angular rates and linear accelerations, and provides high-stability and high-precision measurement capabilities with the use of high-precision compensation technology. A variety of calibration parameters are stored in memory of the IMU, and are automatically reflected in the measurement data being sent to the application after the power of the IMU is turned on.

■ FEATURES

Sensor Spec.	: Gyroscope	Accelerometer
Dynamic Range	: ± 100 or ± 200 °/s (*selectable)	± 3 G
Bias Instability	: 2.2 °/h	0.05 mG
Random Walk	: 0.09 °/√h	0.025 (m/s)/√h
Bias Initial Error	: 360 °/h (1 σ)	5 mG

■ PERFORMANCE CHARACTERISTICS (Gyroscope Allan Variance,M-G364)



IMU M-G354

Wide Dynamic Range IMU

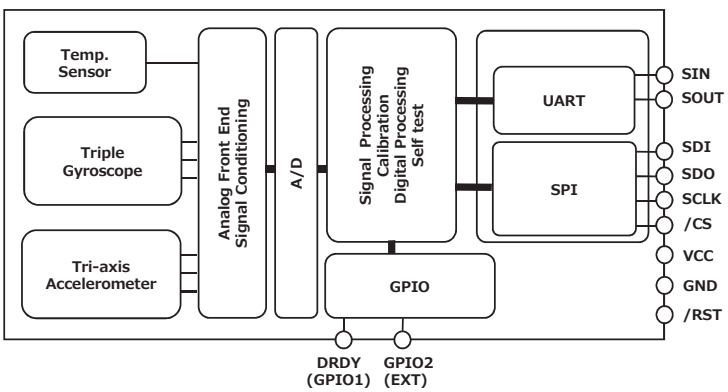
■ GENERAL DESCRIPTION

The M-G354 is a small form factor inertial measurement unit (IMU) with 6 degrees of freedom: triaxial angular rates and linear accelerations, and provides Wide Dynamic Range and high-precision measurement capabilities with the use of high-precision compensation technology. 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.

■ FEATURES

Sensor SPEC.	: Gyroscope	Accelerometer
Dynamic Range	: ± 450 °/s	± 5 G
Bias Instability	: 3 °/h	0.07 mG
Random Walk	: 0.1 °/√h	0.03 (m/s)/√h
Initial Bias Error	: 360 °/h(1 σ)	5 mG

■ FUNCTIONAL BLOCK DIAGRAM AND INTERFACE (M-G364 / M-G354)



Interface
: SPI/UART
Data Output Rate
: ～ 2,000 sps
Temp. Range
(Operating and Calibration)
: – 40 ℃～+ 85 ℃
Power Supply and Current Consumption
: 3.3 V/18 mA (Typ.)

High Stability / Wide Dynamic Range IMU

■ SENSOR SPECIFICATION

T_A=25° C, VCC=3.3 V, angular rate=0 °/s, ≤± 1 G, unless otherwise noted.

Parameter	Test Conditions / Comments	M-G364	M-G354	Unit
GYRO SENSOR				
Sensitivity				
Dynamic Range *3	-	± 100 ／± 200	± 450	°/s
Scale Factor	16 bit, when 32 bit, × 2^16	0.00375 ／ 0.0075	0.016	(°/s)/LSB
Temperature Coefficient	1 σ , – 40 ° C ≤ T_A ≤ +85 ° C	15	15	ppm/° C
Nonlinearity	1 σ , Best fit straight line	0.05	0.05 （≤± 300dps） 0.2 （≥± 300dps）	% of FS
Misalignment	1 σ , Axis-to-axis, Δ = 90 ° ideal	0.02	0.02	°
Bias				
Initial Error	1 σ , – 40 ° C ≤ T_A ≤ +85 ° C	360	360	°/h
Temperature Coefficient (Linear approximation)	1 σ , – 40 ° C ≤ T_A ≤ +85 ° C	1.8	1.8	(°/h)/° C
Bias Instability	Average	2.2	3	°/h
Angular Random Walk	Average	0.09	0.1	°/√h
Linear Acceleration Effect	Average	18	18	(°/h)/G
Noise				
Noise Density	Average , f = 10 Hz to 20 Hz	7.2	8.64	(°/h)/√Hz
Frequency Property				
3 dB Bandwidth	-	200	200	Hz(Max.)
ACCELEROMETERS				
Sensitivity				
Dynamic Range	-	± 3	± 5	G
Scale Factor	16bit, when 32bit, × 2^16	0.125	0.2	mG/LSB
Temperature Coefficient	1 σ , – 40 ° C ≤ T_A ≤ +85 ° C	15	15	ppm/° C
Nonlinearity	1 σ , ≤ 1G, Best fit straight line	0.1	0.1	% of FS
Misalignment	1 σ , Axis-to-axis, Δ = 90 ° ideal	0.01	0.01	°
Bias				
Initial Error	1 σ , – 40 ° C ≤ T_A ≤ +85 ° C	5	5	mG
Temperature Coefficient (Linear approximation)	1 σ , – 40 ° C ≤ T_A ≤ +85 ° C	0.02	0.02	mG/° C
Bias Instability	Average	0.05	0.07	mG
Velocity Random Walk	Average	0.025	0.03	(m/s)/√h
Noise				
Noise Density	Average, f = 10 Hz to 20 Hz	0.06	0.06	mG/√Hz
Frequency Property				
-3 dB Bandwidth	-	200	200	Hz(Max.)
TEMPERATURE SENSOR				
Scale Factor *1 *2	Output = 2634 （0x0A4A） @ +25 ° C	-0.0037918	-0.0037918	° C/LSB

*1) This is a reference value used for internal temperature compensation. We provide 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).
Note) The values in the specifications are based on the data calibrated at the factory. The values may change according to the way the product is used.
Note) The Typ values in the specifications are average values or 1 σ values.
Note) Unless otherwise noted, the Max / Min values in the specifications are design values or Max / Min values at the factory tests.

Water & Dust proof IMU

■ GENERAL DESCRIPTION

The M-G552 Series 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. 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 Controller Area Network (CAN) interface and RS422 interface support for host communication, the M-G552 Series 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 water-proof and dust-proof 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.

■ FEATURES

Size, Weight	: 65 x 60 x 30 mm^3, 115g
Water Proof and Dust Proof	: IP67
Low-Noise, High-Stability	
Gyro Bias Instability	: 0.8 °/h or 1.2 °/h (selected by order code)
Angular Random Walk	: 0.06 °/$\sqrt{h}$ or 0.08 °/$\sqrt{h}$ (selected by order code)
Initial Bias Error	: 360 °/h (1σ)
6 Degrees of Freedom	
Triple Gyroscopes	: ± 450 °/s
Tri-Axis Accelerometer	: ± 5 G
16bit Data Resolution	
Interface	: J1939/CANopen/RS422
Bit Rate	: 500k bps/250k bps(J1939)
	: 1M bps/800k bps/500k bps/250k bps/125k bps/50k bps/20k bps/10k bps(CANopen)
	: 460.8k bps/230.4k bps/921.6k bps(RS422)
Calibrated Stability (Bias, Scale Factor, Axial Alignment)	
Sampling Rate	: to 1,000 Sps Max.(selectable)
Operating Temperature	: −40 ℃ to +80 ℃
Range Single Voltage Supply	: 9 V to 32 V
Low Power Consumption	: 32 mA (Typ.) @Vin = 12 V

■ APPLICATIONS

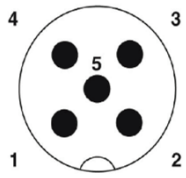
Motion and Vibration Measurement
Platform Stabilization
Attitude Detection for Unmanned Systems
Vibration Control and Stabilization

Water & Dust proof IMU

■ M-G552 SERIES LINE UP

項目		製品型番					
		M-G552PJ1	M-G552PJ7	M-G552PC1	M-G552PC7	M-G552PR1	M-G552PR7
ジャイロセンサー性能	ジャイロバイアス安定性	1.2 °/h	0.8 °/h	1.2 °/h	0.8 °/h	1.2 °/h	0.8 °/h
	角度ランダムウォーク	0.08 °/√h	0.06 °/√h	0.08 °/√h	0.06°/√h	0.08 °/√h	0.06 °/√h
検出範囲	ジャイロセンサー	±450 °/s	±450 °/s	±450 °/s	±450 °/s	±450 °/s	±450 °/s
	加速度センサー	±10 G	±10 G	±10 G	±10 G	±10 G	±10 G
データ解像度		16 bit	16 bit	16 bit	16 bit	16 bit/32 bit	16 bit/32 bit
インターフェイス/プロトコル		J1939		CANopen		RS422	
ビットレート		250 kbps / 500k bps		1M bps(Max.)		460.8k bps/230.4k bps/921.6k bps	
データ出力レート		1000 sps(Max.)		1000 sps(Max.)		2000 sps(Max.)	
ダイナミックチルト出力機能		内蔵	–	内蔵	–	内蔵	–
防水：防塵		IP67					
サイズ		65 mm x 60 mm x 30 mm^3 (突起物を含まず), 115g					
対応規格		FCC part15B(USA), CE(EU)					

■ CAN INTERFACE CONNECTOR SPECIFICATION

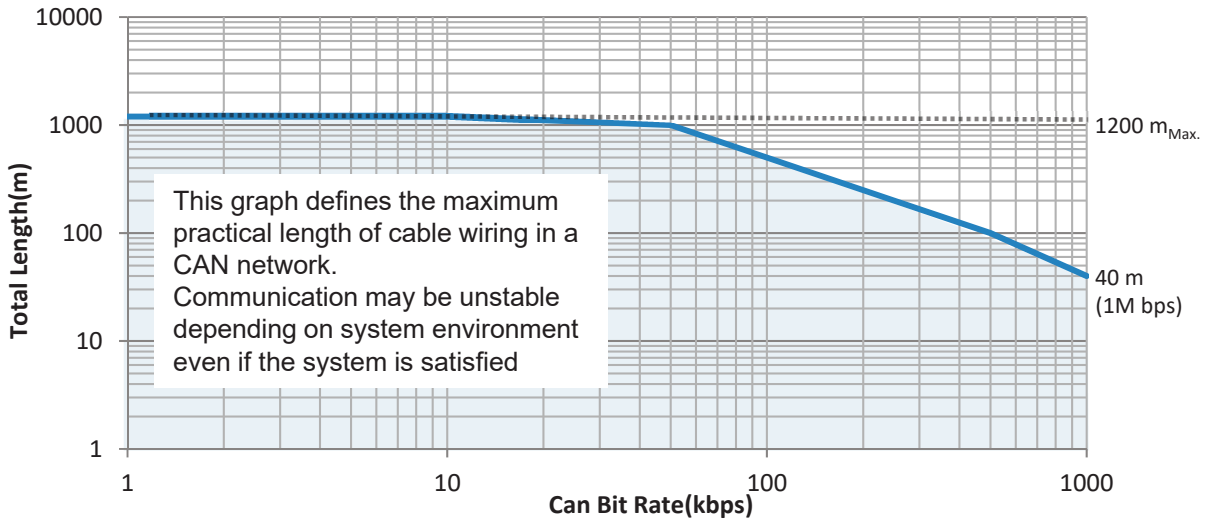


Model number	SACC-DSI-MS-5CON-M12-SCO
Manufacturer	PHOENIX CONTACT

No	Pin Name	Type*2	Description
1	CAN_SHLD	N/A	CAN Shield*1
2	CAN_V+	S	Power supply(9 V-30 V)
3	CAN_GND	S	Ground
4	CAN_H	I/O	CAN H bus line
5	CAN_L	I/O	CAN L bus line

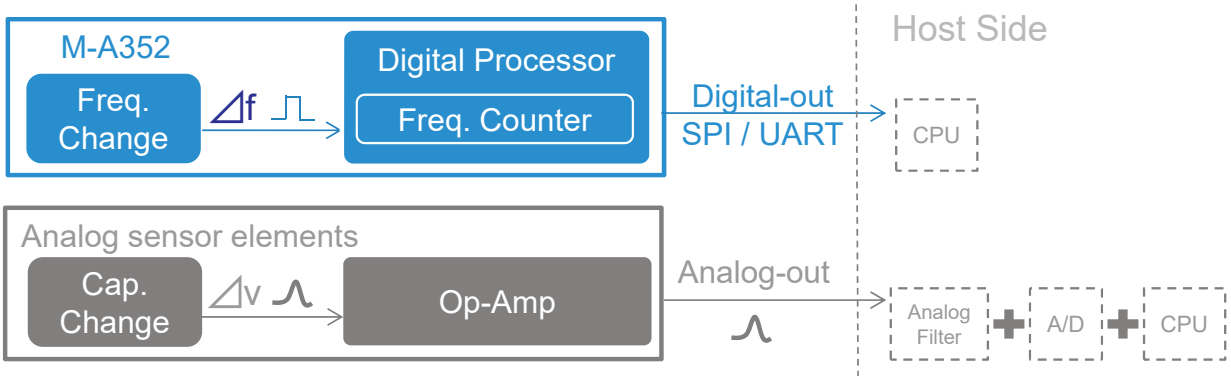
Notice: This unit should be connected to a connector that satisfies at least the IP67 water and dust proof specification.
(*1) CAN_SHLD is connected to the case.
(*2) Pin Type I :Input, O :Output, I/O :Input/Output, S :Supply, N/A :Not Applicable

■ MAXIMUM RECOMMENDED TOTAL LENGTH OF CABLE (Reference)



■ NOISE-RESLIENCE AND DIRECT-DIGITAL-CONVERSION

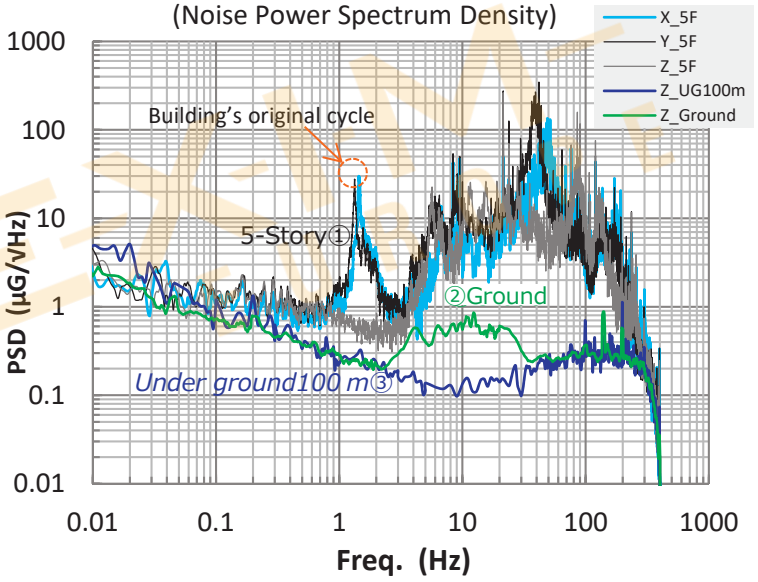
Accelerometer(M-A352/M-A552) is a digital-frequency-change-type of Quartz based accelerometer. This accelerometer can output 32 bit data (0.06 uG/LSB) on each axis without any expensive analog components (such as high-fidelity A/D converter) and is resilient to electricity noise problems typically associated with Si-MEMS-type accelerometers.



■ FOR WIDE RANGE APPLICATIONS

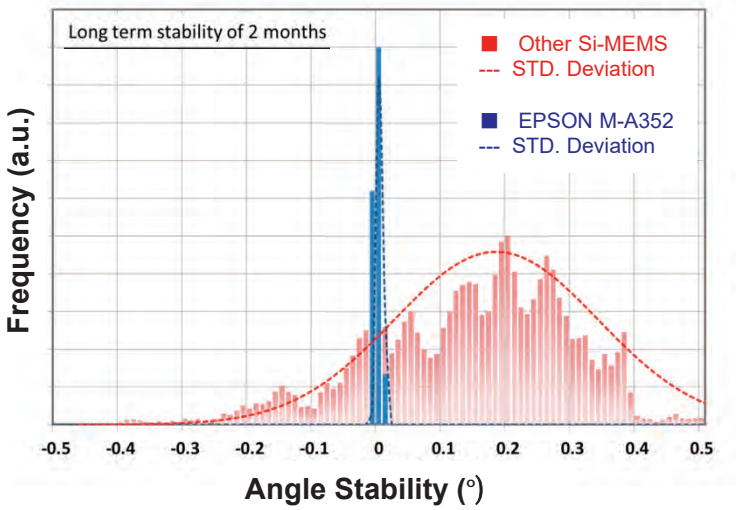
Accelerometer(M-A352/M-A552) can detect slow vibration, small displacement, and high resolution angle and is suitable for structure health monitoring, seismic observation, bridge monitoring and earthquake detection.

Environmental vibration measurement example of a 5-story building
(Noise Power Spectrum Density)

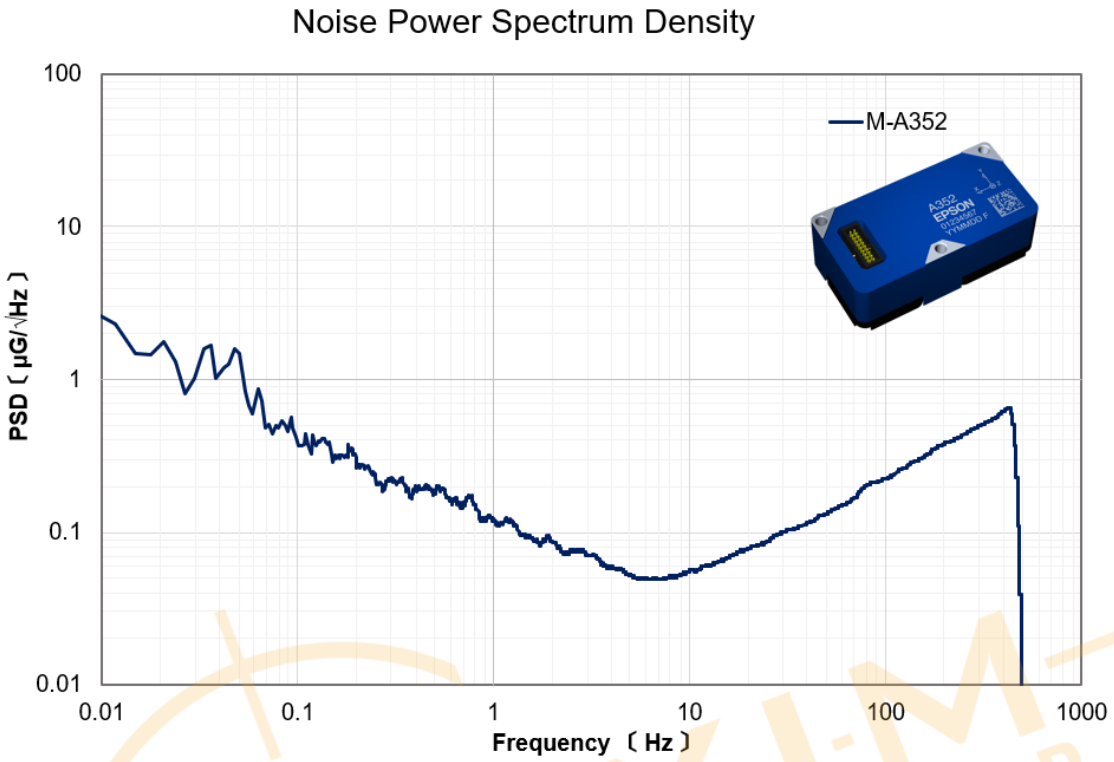


■ High Stability

Accelerometer(M-A352/M-A552) is equipped with a crystal element using micro-fabrication technology of high precision quartz material to enable customer to measure acceleration, or tilt angle with high stability. This is an ideal sensor for analysis and diagnosis of large structures that experience small changes because of its inherent ability to capture highly stable measurements over a long period of time.

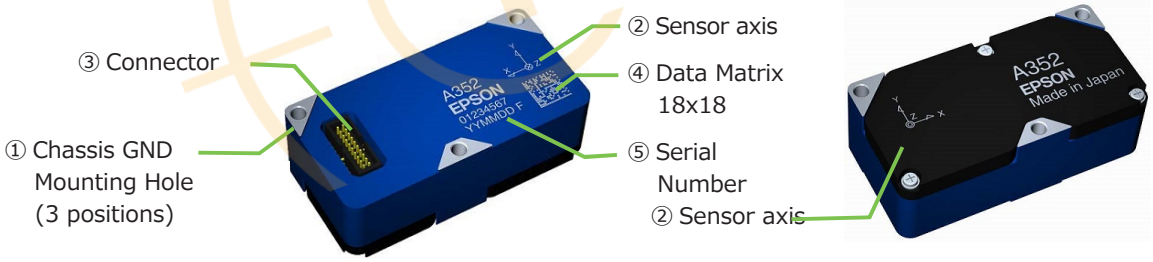


■ TYPICAL PERFORMANCE CHARACTERISTICS
PSD (M-A352)



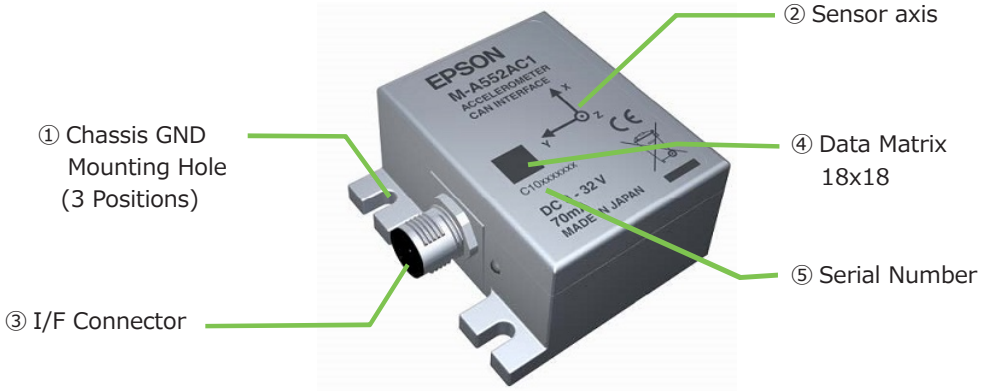
■ HIGH PRECISION AND ROBUST

The M-A352 combines high precision and robustness with a unique quartz sensor element and digital processing technology. The metal case improves shielding, robustness and mounting accuracy. In addition, the platform is shared with the IMU M-G3X series, so substitution with an IMU is possible depending on the application.



■ WATER PROOF UNIT(CAN/RS422 Interface)

M-A552 is a waterproof, dustproof accelerometer with IP-67 equivalent with built-in M-A352. The product is suitable for use in harsh environments such as outdoor installation.



High Precision 3axis Accelerometer

■ GENERAL DESCRIPTION

Accelerometer M-A352 series is a new model capable of wider measurement bandwidth. A highly accurate and stable three axis accelerometer equipped with detection elements made from quartz crystal micro-fabrication technology and wide temperature range by incorporating built-in temperature compensation technology. Using the M-A352 series with the latest generation technology eliminates the need for expensive components such as high fidelity AD converters, analog accelerometers, and noise/wiring challenges associated with legacy analog systems.

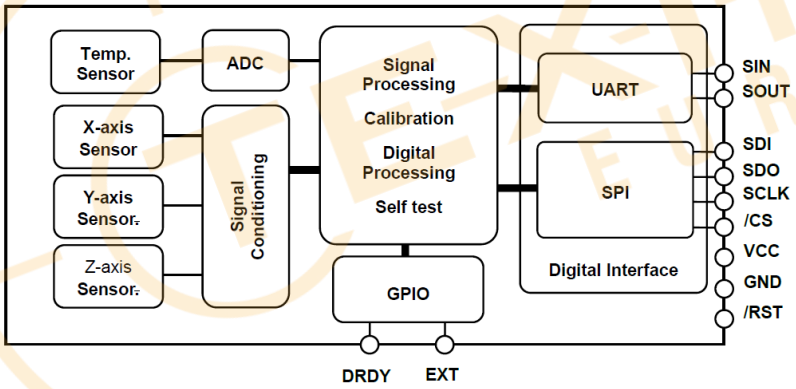
■ FEATURES

Small Size and Light Weight	: 48 x 24 x 16 mm^3, 25 g
Low Noise	: 0.2 μG/√Hz (Average)
High Resolution	: 0.06 μG/LSB
Wide Bandwidth	: DC-460 Hz (selectable)
Output Rate	: 1,000 Sps Max.(selectable)
Tree Axis Accelerometer	: ± 15 G
Digital Serial Interface	: SPI / UART
Wide Operating Temperature Range	: -30 ℃ ～ +85℃
Low Voltage Supply	: 3.3 V, Current Consumption : 13.2 mA
Output Mode Selection(each axis)	: Acceleration, Tilt Angle(selectable by each axis)

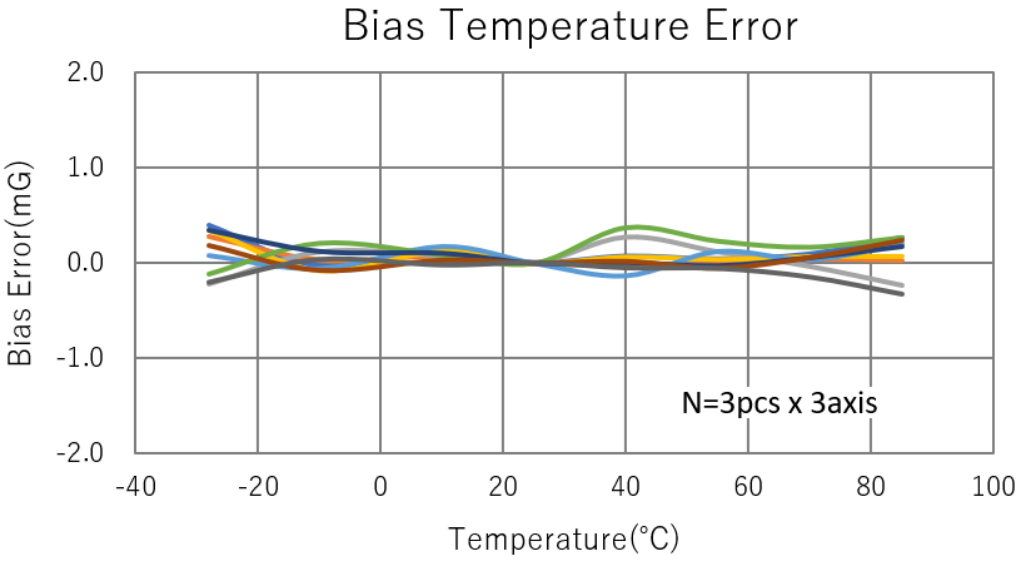
■ APPLICATIONS

Building and Structural Health Monitor, Seismic Observation
Earthquake Detection

■ FUNCTIONAL BLOCK DIAGRAM



■ PERFORMANCE CHARACTERISTICS (Bias Temperature Error)



High Precision 3axis Accelerometer

■ SENSOR SPECIFICATION

T_A=25℃ , VCC=3.3V, ≤± 1G, unless otherwise noted.

Parameter	Test Conditions / Comments	Min.	Typ.	Max.	Unit
ACCELERATION					
Sensitivity					
Output Dynamic Range	f = DC ~ 460Hz	-	-	± 15	G
Scale Factor	-	-	0.06	-	μG/LSB
Sensitivity Error	25 ° C, ≤ 1 G	-	± 500	-	× 10^{-6} (ppm)
Nonlinearity	≤ 1 G, Best fit straight line, RT	-	-	± 0.03	% of FS
Cross Axis Sensitivity	-	-	± 0.2	-	%
Misalignment	1 σ , Axis-to-axis, Δ = 90 ° ideal,RT	-	-	± 0.1	°
Bias					
Initial Error	1 σ , − 40 ° C ≤ T_A ≤ +85 ° C	-	-	± 2	mG
Bias Repeatability	1 year after shipment, TA=25 ° C, VCC=3.3 V	-	3	-	mG
Bias Temperature Error	25 ° C	-	-	± 2	mG
Temperature sensitivity	Maximum Tilt	-	± 0.1	-	mG/℃
Bias Instability	AVR, Average	-	0.2	-	uG
Velocity Random Walk	Average	-	1.2E-4	-	(m/s)/ $\sqrt{hr}$
Noise					
Noise Density	25 ° C, f = 0.5 Hz~6Hz	-	0.2	0.7	μG/$\sqrt{Hz}$
Cantilever Resonance frequency*1	25 ° C, VCC3.3V	-	850	-	Hz
VRC	at 50 Hz 25 °C, VCC3.3 V, Standard Jig300 g	-	-	± 50	μG/G^2
Frequency Property					
-6 dB Bandwidth	User selectable	9	-	460	Hz(max)
TILT ANGLE					
Sensitivity					
Dynamic Range	f = DC ~ 460 Hz	-	-	± 1.0472 (± 60)	rad (°)
Scale Factor	2^{-29} rad/LSB	-	0.002	-	μrad/LSB
Nonlinearity	25 ° C, ± 45 °	-	-	± 0.03	% of FS
Misalignment	1 σ , Axis-to-axis, Δ = 90 ° ideal	-	-	± 1.745 (± 0.1)	mrad (°)
Bias					
Bias Repeatability	25 ° C	-	± 3 (± 0.17)	-	mrad (°)
Bias Temperature Error	25 ° C	-	-	± 2 (± 0.11)	mrad (°)
Noise					
Noise Density	25 ° C, f = 0.5 Hz~6 Hz	-	0.2	0.7	μrad/$\sqrt{Hz}$
TEMPERATURE SENSOR					
Output Range	-	-30	-	85	℃
Scale Factor *2	25 ° C	-	-0.0037918	-	℃ /LSB
COMMON					
Output Data Rate		50		1,000	Sps
Power Supply	Operating voltage range, VCC	3.15	3.3	3.45	V
Power Supply Current	Standard noise floor condition 200 Sps, Average		13.2	18.0	mA

*1 Please make sure that a vibration on this product around the resonance frequency does not exceed 100 mG. Please take an appropriate action (e.g. installing a damper mechanism) if it exceeds 100 mG.
*2 This is a reference value used for the internal temperature correction, and is not guaranteed to accurately output the interior temperature.
Note) The values in the specifications are based on the data calibrated at the factory. The values may change according to the way the product is used.
Note) The Typ values in the specifications are average values or 1 σ values.
Note) The Max/Min value is the maximum/minimum value of the design or factory shipment examination, unless otherwise specified.
Note) The calibrated standard 1G gravitational acceleration value is 9.80665 m/s2

CAN / RS422 Interface
Dust and Water Proof Accelerometer

■ GENERAL DESCRIPTION

M-A552 sensor unit uses the latest technology to improve performance and offer wider sensing bandwidth. With Controller Area Network (CAN) interface or RS422 interface supported for host communication, the M-A552 reduces technical barriers for users to incorporate seismic and vibration sensing, and minimizes design resources to implement control and monitoring applications. This unit is packaged in a water-proof and dust-proof metallic case making it suitable for use in industrial and heavy-duty applications.

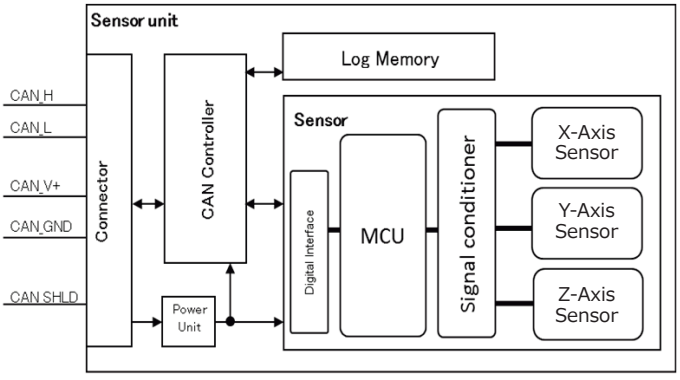
■ FEATURES

Integrated Sensor	: M-A352
High Resolution	: 0.06 μG/LSB
Wide Bandwidth	: DC ～ 460 Hz (selectable)
Tree axis accelerometer	: ± 15 G
Output Rate	: ~ 1,000 Sps Max. (selectable)
Digital Serial Interface (M-A552AC1)	: CANopen (ISO11898-2 High speed CAN)
(M-A552AR1)	: RS422(TX/RX, 4-wire full duplex communication)
Single Voltage Supply	: 9 V ～ 32V
Low Power Consumption(M-A552AC1)	: 35 mA (Typ.) @Vin=12 V
(M-A552AR1)	: 49 mA (Typ.) @Vin=12V
Operating Temperature Range	: − 30 ℃ ～ +70 ℃
Size	: 65 × 60 × 30 mm^3 (including projections)
Weight	: 128 g
Water and Dust Proof	: IP67
Corresponding standard	
CE	: CE Marking(EN61326、RoHS)
FCC	: FCCpart15B ClassA

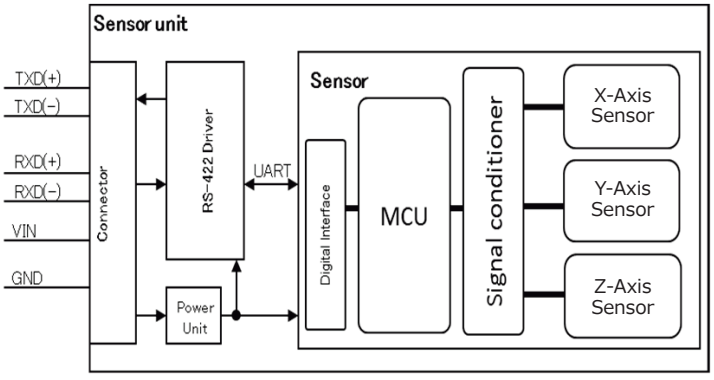
■ APPLICATION

Building and Structural Health Monitor
Seismic Observation
Earthquake Detection

■ FUNCTIONAL BLOCK DIAGRAM



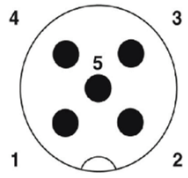
CAN Interface M-A552AC1



RS422 Interface M-A552AR1

CAN / RS422 Interface
Dust and Water Proof Accelerometer

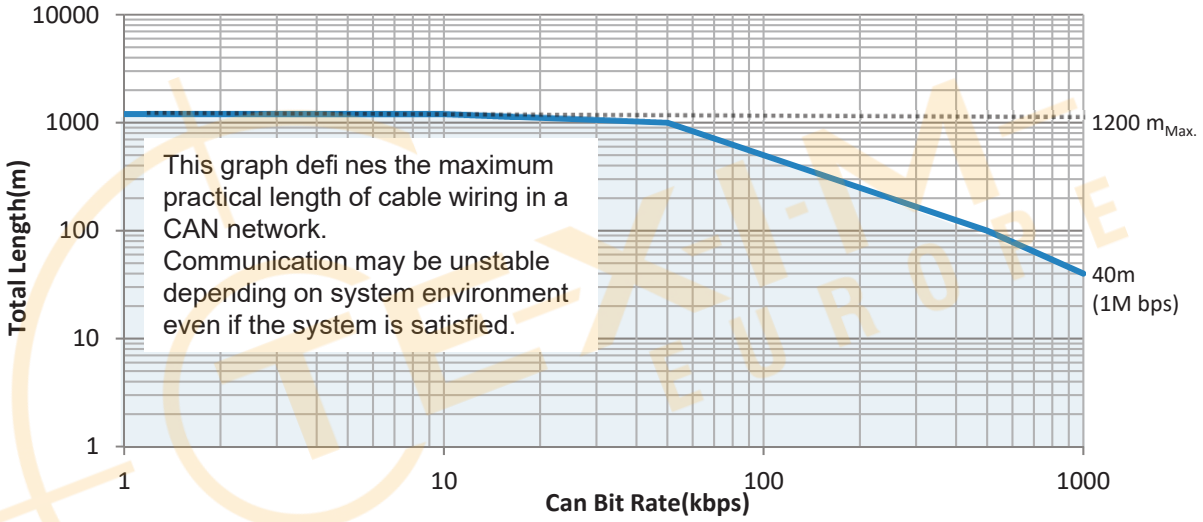
■ CAN INTERFACE CONNECTOR SPECIFICATION (M-A552AC1)



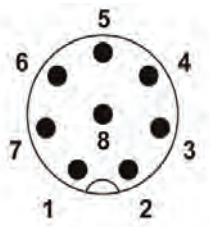
Model number	SACC-DSI-MS-5CON-M12-SCO
Manufacturer	PHOENIX CONTACT

No	Pin Name	Type*2	Description
1	CAN_SHLD	N/A	CAN Shield*1
2	CAN_V+	S	Power supply（9 V-32V)
3	CAN_GND	S	Ground
4	CAN_H	I/O	CAN H bus line
5	CAN_L	I/O	CAN L bus line

■ MAXIMUM RECOMMENDED TOTAL LENGTH OF CABLE (Reference, M-A552AC1)



■ RS422 INTERFACE CONNECTOR SPECIFICATION (M-A552AR1)



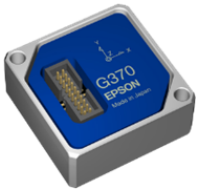
Model number	SACC-DSI-MS-8CON-M12-SCO SH
Manufacturer	PHOENIX CONTACT

No	Pin Name	Type*2	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（-)

Notice: This unit should be connected to a connector that satisfies at least the IP67 water and dust proof specification.
(*1) CAN_SHLD is connected to the case.
(*2) Pin Type I :Input, O :Output, I/O :Input/Output, S :Supply, N/A :Not Applicable

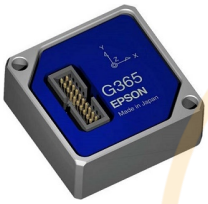
■ IMU APPLICATION EXAMPLES

Agriculture



M-G370

Stabilization



M-G365

Construction and Mining Machine Control

M-G552

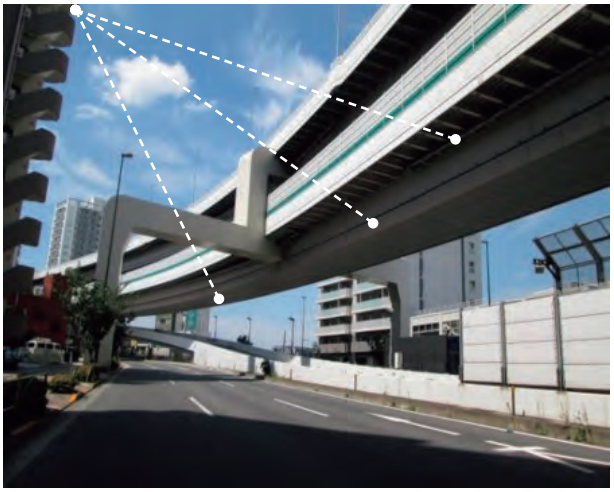
■ ACCELEROMETER APPLICATION EXAMPLES

Structure Health Monitoring (SHM)

M-A352

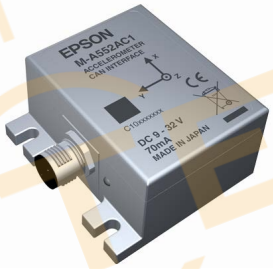
M-A552

Bridge Monitoring

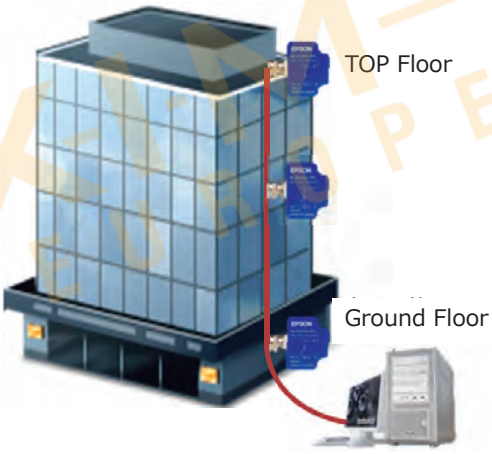


Building and Earthquake Monitoring, Maintenance

M-A352

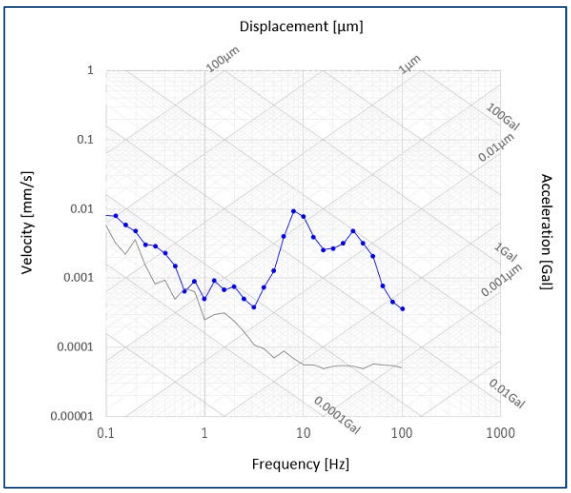


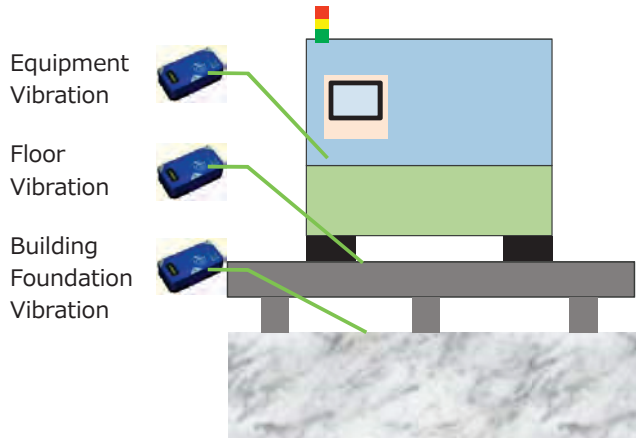
M-A552



Multi-sensor Measurement System with CAN Interface

Vibration Analysis with Tripartite Chart

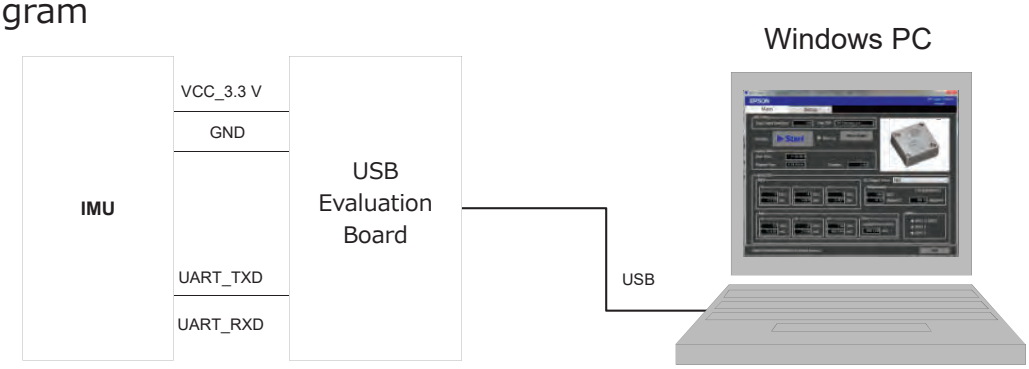




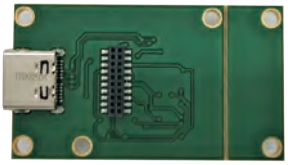
■ EVALUATION KIT

This USB Evaluation Cable Interface Board enables a PC to control the Epson IMU and Accelerometer via USB interface when used with the USB Evaluation Cable and boards. The USB evaluation tools simplify the initial evaluation and rapid testing of the Epson IMU and Accelerometer products. The power is supplied from USB power.

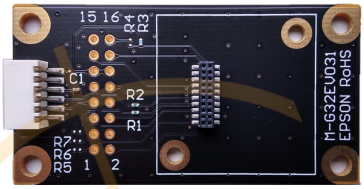
● Block Diagram



● Evaluation Board



Evaluation Board
(M-G32EV041)

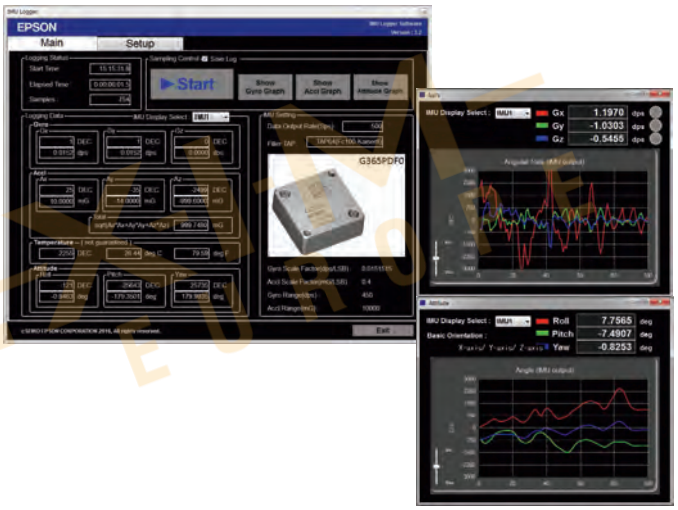


Evaluation Board
(M-G32EV031)

Evaluation Board
(M-G32EV051)

USB Type-C

Logger software for Windows
Downloadable on EPSON Website.



● Combination Table

Usage	USB Cable Evaluation Cable	Evaluation Board	IMU / Accelerometer	Products
Data logger on PC	USB Type-C	M-G32EV041	IMU	M-G370 M-G365 M-G354PD M-G364PDC0 M-G364PDCA
	USB Type-C	M-G32EV041 +M-G32EV051	Accelerometer	M-A352AD
Built in customer board	---	M-G32EV031	IMU	M-G370 M-G365 M-G354PD M-G364PDC0 M-G364PDCA
		M-G32EV051	Accelerometer	M-A352AD

Texim Europe - contact details

Headquaters & Warehouse

Elektrostraat 17
NL-7483 PG Haaksbergen
The Netherlands

T: +31 (0)53 573 33 33
E: info@texim-europe.com
Homepage: www.texim-europe.com

The Netherlands

Elektrostraat 17
NL-7483 PG Haaksbergen

T: +31 (0)53 573 33 33
E: nl@texim-europe.com

Belgium

Zuiderlaan 14, box 10
B-1731 Zellik

T: +32 (0)2 462 01 00
E: belgium@texim-europe.com

UK & Ireland

St Mary's House, Church Lane
Carlton Le Moorland
Lincoln LN5 9HS

T: +44 (0)1522 789 555
E: uk@texim-europe.com

Germany - North

Bahnhofstrasse 92
D-25451 Quickborn

T: +49 (0)4106 627 07-0
E: germany@texim-europe.com

Germany - South

Martin-Kollar-Strasse 9
D-81829 München

T: +49 (0)89 436 086-0
E: muenchen@texim-europe.com

Austria

Warwitzstrasse 9
A-5020 Salzburg

T: +43 (0)662 216 026
E: austria@texim-europe.com

Nordic

Søndre Jagtvej 12
DK-2970 Hørsholm

T: +45 88 20 26 30
E: nordic@texim-europe.com

Italy

Via Matteotti 43
IT-20864 Agrate Brianza (MB)

T: +39 (0)39 9713293
E: italy@texim-europe.com

■ Global Network

In order to understand the customer needs around the world and respond quickly, we are expanding our bases globally and providing services closely to customers.

NORTH AMERICA
Epson America, Inc.
https://epson.com/microdevices
214 Devcon Drive, San Jose,
CA 95112, U.S.A.
TEL +1-800-228-3964, FAX +1-408-922-0238

EUROPE
Epson Europe Electronics GmbH
https://www.epson-electronics.de/
Riesstrasse 15, 80992 Munich, Germany
TEL +49-89-14005-0, FAX +49-89-14005-110

CHINA
Epson (China) Co., Ltd.
https://www.epson.com.cn/
4F,Tower 1 of China Central Place,81 Jianguo Street,
Chaoyang District, Beijing 100025 China
TEL +86-400-810-9972 X ext.2,
Mail EPSON_MSM@ecc.epson.com.cn

SINGAPORE
Epson Singapore Pte. Ltd.
https://www.epson.com.sg/
438B Alexandra Road, Block B Alexandra TechnoPark,
#04-01/04, Singapore 119968
TEL +65-6586-5500, FAX +65-6271-3182

JAPAN and OTHER AREA
SEIKO EPSON CORPORATION
DEVICE SALES & MARKETING DEPT.

29th Floor, JR Shinjuku Miraina Tower, 4-1-6 Shinjuku,
Shinjuku-ku, Tokyo, 160-8801, Japan
TEL : +81-3-6682-4322, FAX : +81-3-6682-5016

Nakanoshima Daibiru 22F,
3-3-23 Nakanoshima, Kita-ku, Osaka-shi
Osaka 530-6122, Japan
TEL : +81-6-7711-6770, FAX : +81-6-7711-6771

KOREA
Epson Korea Co., Ltd.
https://www.epson.co.kr/
10F Posco Tower Yeoksam, Teheranro 134
Gangnam-gu, Seoul, 06235 KOREA
TEL +82-2-558-4270, FAX +82-2-3420-6699

TAIWAN
Epson Taiwan Technology & Trading Ltd.
https://www.epson.com.tw/
15F., No.100, Songren Rd., Xinyi Dist., Taipei City
11073,Taiwan (R.O.C.)
TEL +886-2-8786-6688, Fax +886-2-8786-6600

PRODUCT WEBSITE

For further information about our products. Please visit our Website.
ENGLISH: https://global.epson.com/products_and_drivers/sensing_system/
JAPANESE: https://www.epson.jp/prod/sensing_system/

EPSON
EXCEED YOUR VISION

2021. 07