



MS IMU
3050



Product Specification & User Guide

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1.0 OVERVIEW

The MS-IMU3050 delivers extreme performance in a compact durable aluminum package at a value point that is unmatched. The gyro bias instability of 0.3 °/h combined with an angle random walk of 0.065 °/h^{-1/2} provide low drift performance supporting a range of applications from pipeline inspection to navigation systems. The accelerometer bias instability of 2.6 µg and ultra-low noise density (14 µg/√Hz) provide increased accuracy in orientation applications. User configurable options allow the IMU to be tuned to your application with configurable bandwidth, sample rate, gyro ranges, accel ranges, 1 PPS input and other measurement parameters. The MS-IMU3050 provides all these benefits in a package that only

measures 1.8 x 1.6 x 0.98 inches with a mass of only 90 grams. The MS-IMU3050's combination of performance, size, configurability, and value surpasses all IMUs in the high performance MEMS IMU market.



2.0 SPECIFICATIONS

Table 1 – Specifications

ACCELEROMETER	MP00067-001 & MP00067-002			UNITS	NOTES
Dynamic Range	± 2	± 4	± 8	g	Note 1
Bias Instability	2.6	2.6	2.6	µg	Typical
Offset	± 670	± 670	± 670	µg	Typical
Nonlinearity	± 0.3	± 0.3	± 0.3	% of FS	Typical
Velocity Random Walk	0.006	0.006	0.006	m/s/h ^{-1/2}	Typical
Noise Density	14	14	14	µg/Hz ^{-1/2}	Typical
Bandwidth			50	Hz	-3dB point, Note 2
ACCELEROMETER	MP00067-003 TO MP00067-008			UNITS	NOTES
Dynamic Range	± 10	± 20	± 40	g	Note 3
Bias Instability	7.5	7.5	7.5	µg	Typical
Offset	± 550	± 550	± 550	µg	Typical
Nonlinearity	± 0.3	± 0.3	± 0.3	% of FS	Typical
Velocity Random Walk	0.02	0.02	0.02	m/s/h ^{-1/2}	Typical
Noise Density	45	45	45	µg/Hz ^{-1/2}	Typical
Bandwidth			50	Hz	-3dB point, Note 2

1. Available accelerometer ranges in the MP00067-001 and MP00067-002 only.
2. Bandwidth is configurable see Section 4.4.2 Filter Configure.
3. Available accelerometer ranges in the MP00067-003 to MP00067-008 only.

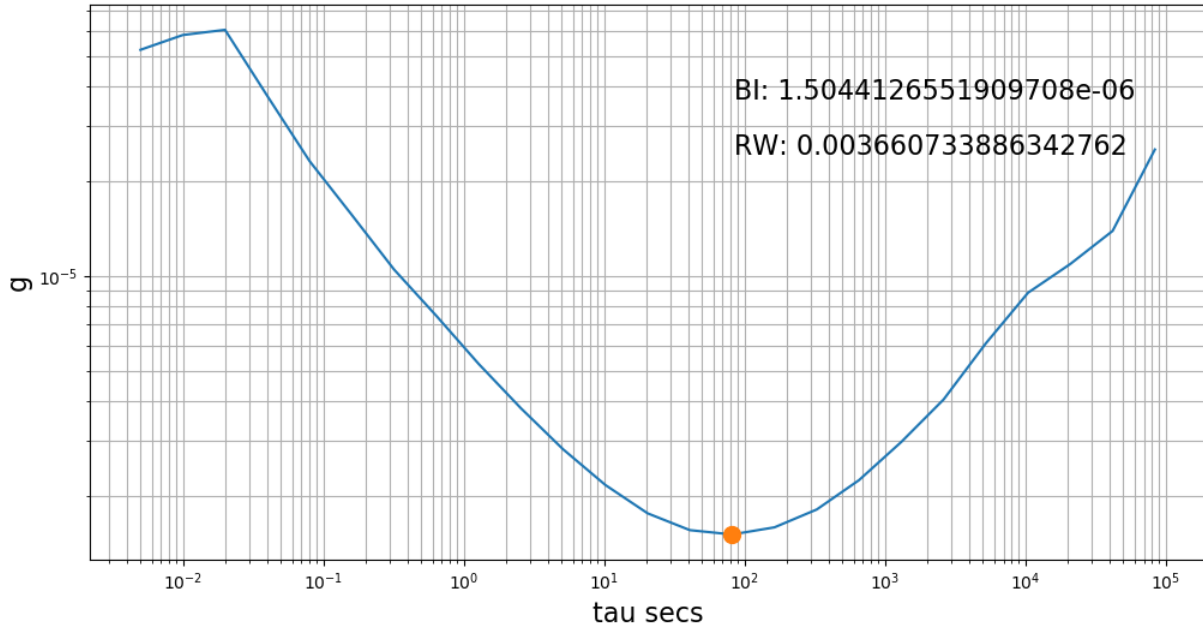
ANGULAR RATE						UNITS	NOTES	
Dynamic Range	± 75	± 200	± 480	± 960	± 1920	°/s	Minimum, Notes 4 & 5	
Bias Instability	0.33	0.33	0.33	0.33	0.33	°/h	Typical XY	
	0.22	0.22	0.22	0.22	0.22		Typical Z	
Offset	± 5	± 5	± 5	± 5	± 5	°/h	Typical	
Nonlinearity	± 0.05	± 0.05	± 0.05	± 0.05	± 0.05	% of FS	Typical, Note 3	
Angle Random Walk	0.08	0.08	0.08	0.08	0.08	°/h ^{-1/2}	Typical XY	
	0.05	0.05	0.05	0.05	0.05		Typical Z	
Noise Density	0.002	0.002	0.002	0.002	0.002	°/s /Hz ^{-1/2}	Typical XY	
	0.0014	0.0014	0.0014	0.0014	0.0014		Typical Z	
Bandwidth						50	Hz	-3dB point, Note 2
MAGNETIC FIELD						UNITS	NOTES	
NOTE 6								
Dynamic Range						± 1.9	gauss	Minimum
Offset						± 0.005	gauss	Typical
Noise Density						79.2	µgauss /Hz ^{-1/2}	Typical
Bandwidth						50	Hz	-3dB point
DEVICE TEMPERATURE						UNITS	NOTES	
Temperature Error						± 1.5	°C	Maximum
EXTERNAL TRIGGER INPUT								
Voltage Low Level Input						0.94	V	Maximum
Voltage High Level						1.65	V	Minimum
Pulse Width						1.0	µs	Minimum
TIME OF VALIDITY OUTPUT								
Voltage Low Level						0.4	V	Maximum
Voltage High Level						2.6	V	Minimum
Rise and Fall Time						30	ns	Maximum
PHYSICAL						UNITS	NOTES	
Dimensions						1.80 × 1.60 × 0.98	in.	(L x W x H)
Mass						90	grams	
OPERATIONAL REQUIREMENTS						UNITS	NOTES	
Supply Voltage						4.9 to 30.0	VDC	
Supply Power						2.5	W	Typical
Operating Temperature						-40 to 85	°C	
Interface Connector						Harwin Gecko G125-MS11005L		10 pin
Mating Connector						Harwin Gecko G125-2041096L0		10 pin
ABSOLUTE MAXIMUM RATINGS						UNITS	NOTES	
NOTE 7								
Acceleration Powered						800	g	0.5 ms any axis
Supply Voltage						-0.3 (min) to 36.0 (max)	VDC	
Storage Temperature						-55 to 85	°C	

4. Dynamic ranges configurable via software: ±75°/s, ±200°/s, ±480°/s, ±960°/s, and ±1920°/s in the MP00067-001 and MP00067-002.
5. Dynamic ranges configurable via software: ±75°/s, ±200°/s, and ±480°/s in the MP00067-003 and MP00067-004.
6. Nonlinearity is specified from -30 to 85°C at angular rate of ±450 °/s.
7. Absolute Maximum Ratings list device survivability specifications and are non-operational.
8. Typical Values at 25°C, 0 °/s, unless otherwise noted.

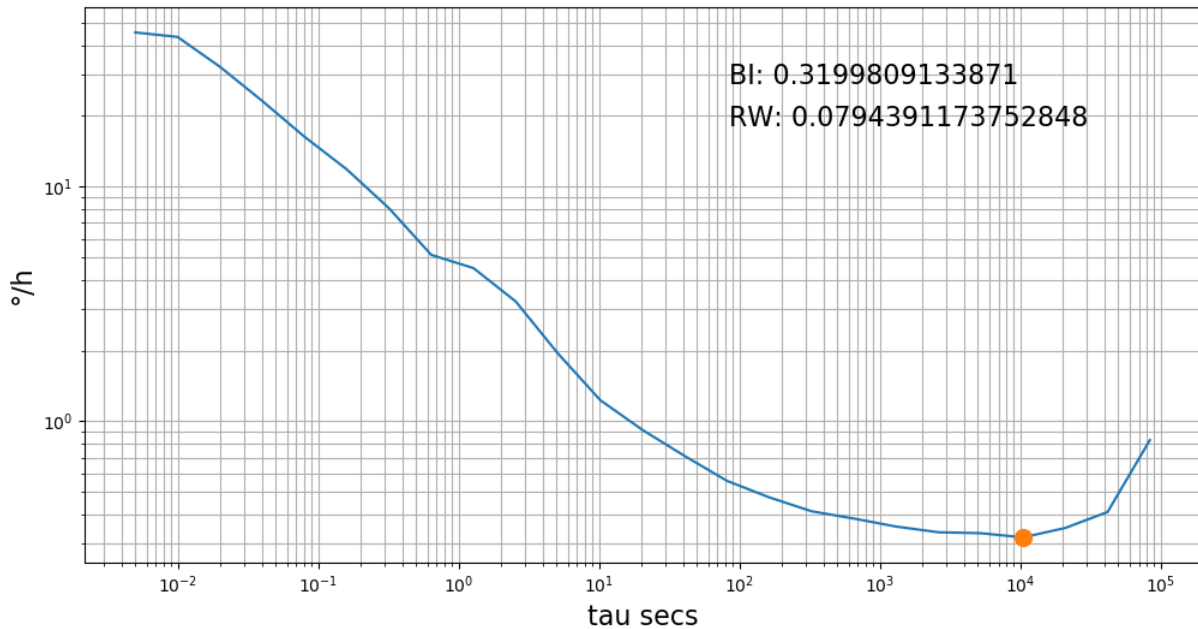
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MS-IMU3050 ALLAN VARIANCE CURVES

Accelerometer Root Allan Variance



Gyroscope Root Allan Variance



3.0 MECHANICAL

3.1 Dimensions

The MS-IMU3050 is contained in a 6061-T6 aluminum housing anodized to MIL-A-8625 standards. Mounting of the IMU is achieved through four 2-56 captive socket head cap screws while alignment is facilitated through two one sixteenth inch dowel pins. The mounting surface of the mechanical interface is flat to within one one-thousandths of an inch. The dimensions below are only an overview of the housing, detailed mechanical drawings in Imperial and Metric units are provided at Memsense.com under the MS-IMU3050 product page.

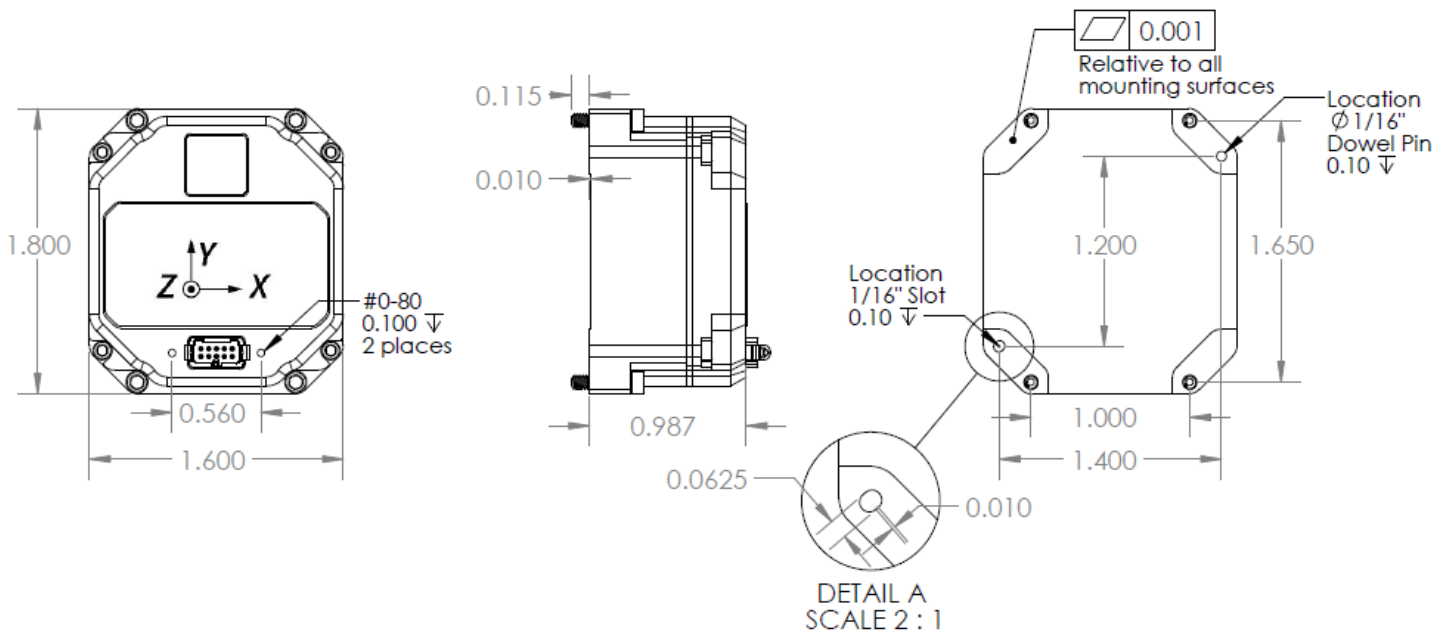


Figure 1 - Physical dimensions (inches)

3.2 Coordinate System

The coordinate system for the MS-IMU3050 follows the right hand rule convention. As an example, with the IMU pictured in Figure 2, if the Z axis is pointed straight UP away from the earth, it will produce 0 g for the X and Y axes and a positive 1 g for the Z axis. A counterclockwise rotation of the IMU about any of the depicted axis will produce a positive angular rate output for the corresponding axis. The magnetometer sign convention produces a positive output on the corresponding axis aligned in the North direction with the IMU bottom parallel and facing the Earth's surface.



Figure 2 – MS-IMU3050 coordinate system

4.0 COMMUNICATIONS

4.1 Default Communication Settings

The MS-IMU3030 is configured in manufacture to default settings. Knowledge of these settings is important when connecting to the IMU in the MS-CIP Evaluation Application. The following table provides the necessary default settings to connect to the IMU.

Table 2 –IMU Default Settings

Setting	Default
Baud Rate	460800 bps
Sample Rate Decimation	4
Filter Cutoff	50 Hz
Gyro Range	±480 °/s
Accel Range	±2 g ¹
Sensor Select	Angular Rate and Acceleration

Note 1: Default accel range in the MP00067-003 and MP00067-004 is ±20g.

4.2 Hardware Interface

The MS-IMU3050 utilizes a 1.25mm pitch 10-pin Harwin Gekco connector for an electrical interface. The IMU connector manufacturer part number is G125-MS11005L with a mating connector manufacturer part number of G125-2041096L0. The IMU communications are transmitted and received via 3.3 volt level RS-422 physical signals. The IMU also receives a single ended 3.3 volt input to signal a one pulse per second synchronization from a GPS receiver. The electrical interface is further detailed in the figure and table below.

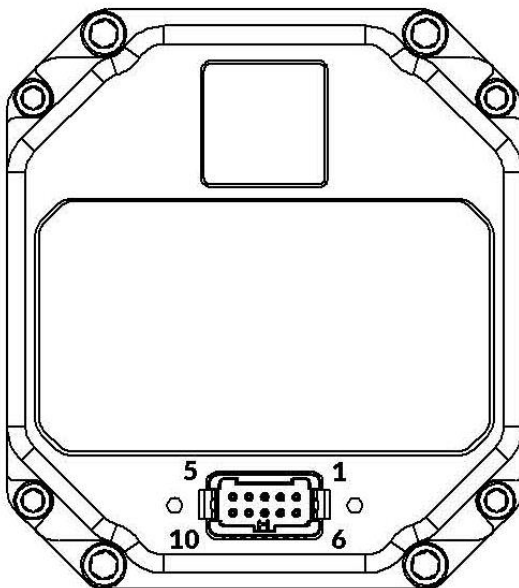


Figure 3 – MS-IMU3050 electrical interface connector

Table 3 – MS-IMU3050 Signal Interface

PIN	SIGNAL	DESCRIPTION
1	PWR	Power Supply Input
2	RSVD	Reserved
3	1PPS	GPS 1 Pulse Per Second Input
4	RCV A	RS-422 Non-Inverting Input
5	RCV B	RS-422 Inverting Input
6	GND	Power Supply Return
7	TOV	Time Of Validity
8	X TRIG	External Trigger
9	TX Y	RS-422 Non-Inverting Output
10	TX Z	RS-422 Inverting Output

4.2.1 Time of Validity Output – Internal Sample Rate

The *Time of Validity (TOV)*, pin 7, output provides a signal that indicates when the internal sensors are sampled at the internal sample rate and when the samples complete transmission. The TOV falling edge is correlated with sampling of the first element in a sample. The TOV rising edge occurs after the last bit of a sample has finished transmission. Figure 4 provides a timing diagram depicting the relation between the internal sample rate, sample transmission and the TOV output. See 4.2.2 External Trigger Input for TOV output with external trigger enabled.

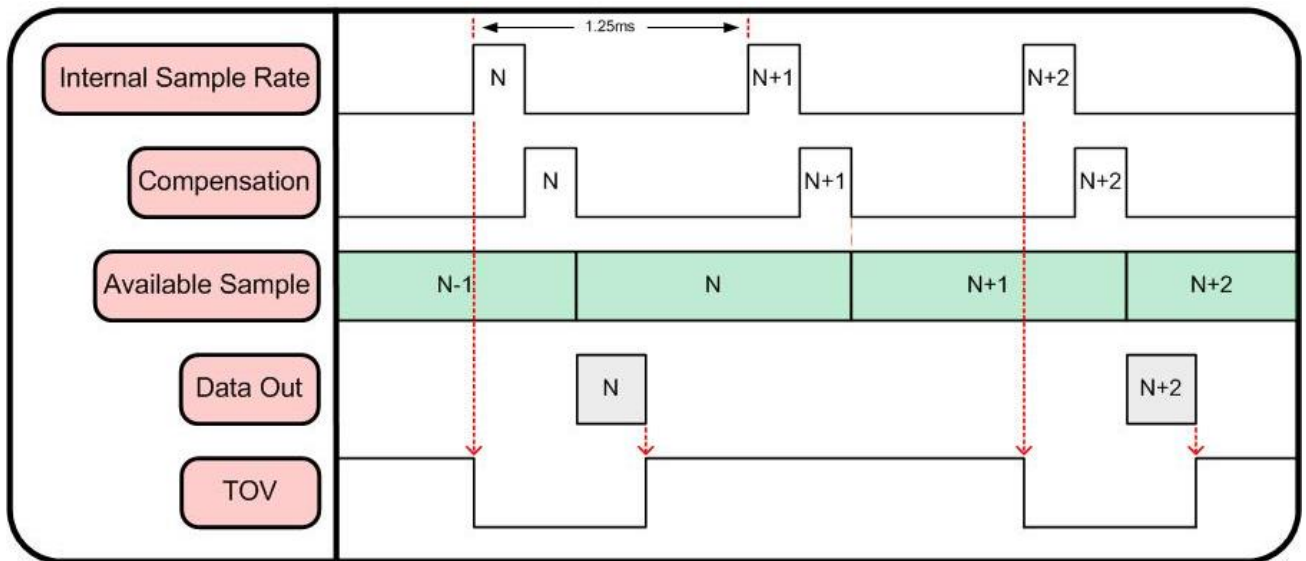


Figure 4 – TOV timing diagram with output sample rate at decimation of 2.

4.2.2 External Trigger Input

The *External Trigger (X TRIG)*, pin 8, input provides a means to synchronize the IMU’s sample transmission with an external sampling period. A falling edge signal on the External Trigger input initiates the transmission of the most recent complete sample. When in the External Trigger Mode, the TOV falling edge occurs with the beginning of an internal sample and its rising edge is initiated by the completion of the sample’s compensation. Figure 5 depicts the timing associated with the use of the External Trigger and its relation to the TOV signal.

Please note that the External Trigger Mode must be enabled through the communications protocol for the input to be active, see the protocol section or the MS-CIP specification for details on enabling or disabling the External Trigger.

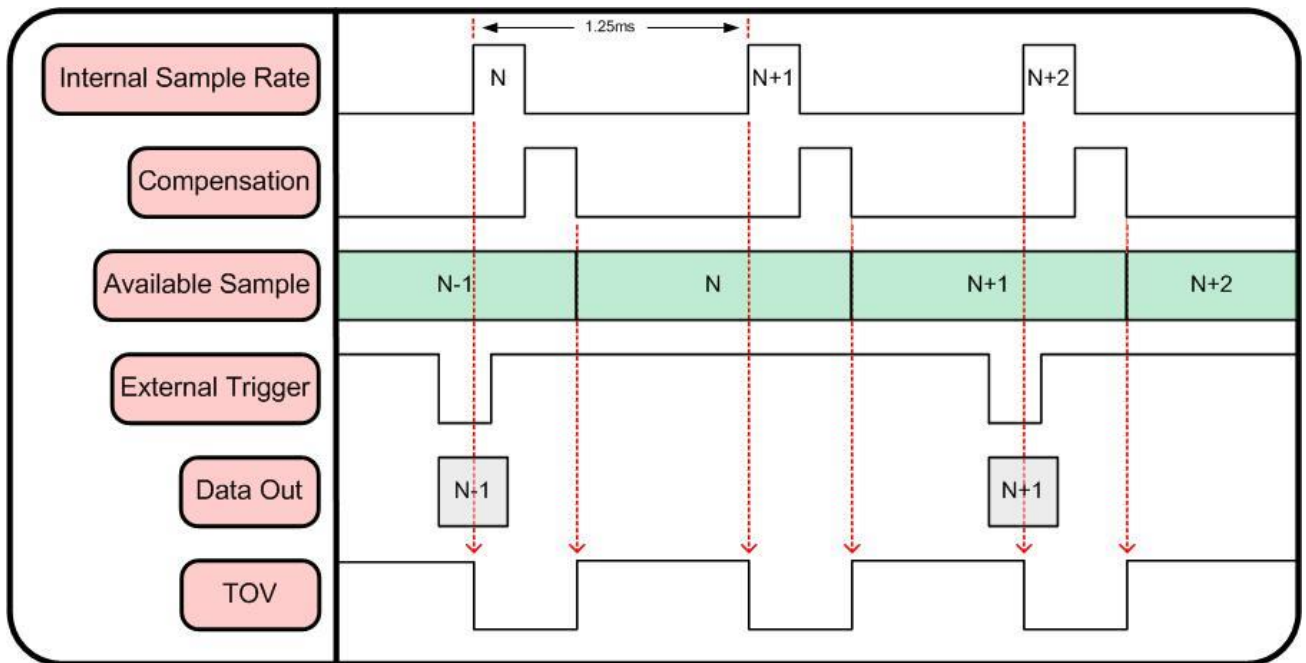


Figure 5 – External Trigger timing diagram.

4.3 Internal Sample Rate

The MS-IMU3050 internally samples sensors selected by the configuration at a rate of 800 samples per second. The internal sample rate is used in the output sample rate configuration detailed in the Memsense Communication Interface Protocol.

4.4 Communication Interface Protocol

The communication interface protocol is defined in detail in the Memsense Communication Interface Protocol document (MS-CIP DOC00381) which can be found on the MS-IMU3050 product page at memsense.com. The following information contains MS-IMU3050 specific portions of the communication protocol.

The Memsense Communication Interface Protocol (MS CIP) is implemented as a simple architecture to communicate information to and from the measurement device. The protocol is intended to be flexible in allowing customers to configure various features of the device achieving optimized communication modes for various application requirements. Below is a table showing the default output from the MS-IMU3050.

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Table 4 – Default IMU Data Message 0xA2

Byte	Byte Name	Value	Description
0	Sync1	0xA5	First synchronization value used in sample parsing.
1	Sync2	0xA5	Second synchronization value used in sample parsing.
2	Message Type	0xA2	Message type identification code.
3	Payload Size	0x1C	Byte length of the payload.
4	Message Code	0x81	Scaled Acceleration Vector identification code.
5	Data Size	0x0C	Data Size in bytes.
6	X Accel MSB	0x37	X Accel in g. MSB of F32.
7	X Accel Byte 2	0xA7	X Accel in g. Byte 2 of F32.
8	X Accel Byte 1	0xC5	X Accel in g. Byte 1 of F32.
9	X Accel LSB	0xAC	X Accel in g. LSB of F32.
10	Y Accel MSB	0x37	Y Accel in g. MSB of F32.
11	Y Accel Byte 2	0x7B	Y Accel in g. Byte 2 of F32.
12	Y Accel Byte 1	0xA8	Y Accel in g. Byte 1 of F32.
13	Y Accel LSB	0x82	Y Accel in g. LSB of F32.
14	Z Accel MSB	0x3F	Z Accel in g. MSB of F32.
15	Z Accel Byte 2	0x80	Z Accel in g. Byte 2 of F32.
16	Z Accel Byte 1	0x00	Z Accel in g. Byte 1 of F32.
17	Z Accel LSB	0x65	Z Accel in g. LSB of F32.
18	Message Code	0x82	Scaled Angular Rate Vector identification code.
19	Data Size	0x0C	Data Size in bytes.
20	X Gyro MSB	0x37	X Gyro in degrees per second. MSB of F32.
21	X Gyro Byte 2	0xA7	X Gyro in degrees per second. Byte 2 of F32.
22	X Gyro Byte 1	0xC5	X Gyro in degrees per second. Byte 1 of F32.
23	X Gyro LSB	0xAC	X Gyro in degrees per second. LSB of F32.
24	Y Gyro MSB	0x37	Y Gyro in degrees per second. MSB of F32.
25	Y Gyro Byte 2	0x7B	Y Gyro in degrees per second. Byte 2 of F32.
26	Y Gyro Byte 1	0xA8	Y Gyro in degrees per second. Byte 1 of F32.
27	Y Gyro LSB	0x82	Y Gyro in degrees per second. LSB of F32.
28	Z Gyro MSB	0x37	Z Gyro in degrees per second. MSB of F32.
29	Z Gyro Byte 2	0x49	Z Gyro in degrees per second. Byte 2 of F32.
30	Z Gyro Byte 1	0x53	Z Gyro in degrees per second. Byte 1 of F32.
31	Z Gyro LSB	0x9C	Z Gyro in degrees per second. LSB of F32.
32	Checksum 1	0x0C	Fletcher-16 checksum block 1 MSB
33	Checksum 2	0x23	Fletcher-16 checksum block 2 LSB
Resulting Complete Command			

A5A5A21C810C37A7C5AC377BA8823F800065820C37A7C5AC377BA8823749539C0C23

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4.4.1 IMU Sample Rate Configure 0x0204

The *IMU Sample Rate Configure* provides a means to configure and save the rate at which all IMU data messages are transmitted. *IMU Message Config* is used to control individual measurements.

The *IMU Sample Rate Configure* function codes define the function to be performed on the device’s inertial measurements. The associated codes and functions are listed in Table 5 below.

Table 5 – IMU Sample Rate Function Codes

Code	IMU Sample Rate Function
0X01	Use new settings.
0x02	Request current settings.
0x03	Save current settings as startup settings.
0x04	Load saved startup settings.
0x05	Reset to default settings.

A 16-bit decimation value must be provided and is used to divide the internal sample rate to the desired output sample rate. The MS-IMU3050 has an internal sample rate of 800Hz therefore providing a decimation value of 0x0008 (8 decimal) configures the output sample rate to 100Hz.

See the MS-CIP at memsense.com under the MS-IMU3050 product page for more details regarding IMU Sample Rate Configure.

4.4.2 Configure Filter 0x0203

The *Configure Filter* message provides a means for configuring and saving internal digital filtering options. The *Filter Function* allows the configuration to be used, queried, saved, loaded from startup settings, and reset to defaults. Table 6 details the associated codes and functions.

Table 6 –Filter Function Codes

Code	Filter Function
0X01	Use new settings.
0x02	Request current settings.
0x03	Save current settings as startup settings.
0x04	Load saved startup settings.
0x05	Reset to default settings.

The *Filter Control* codes allow filtering to be disabled or enabled in Infinite Impulse Response (IIR) mode. Care in selecting a filter bandwidth value that supports the Nyquist Sampling Theorem is suggested. The filter cutoff options listed here are specific to the MS-IMU3050. Filter cutoff options for the MS-IMU3050 are listed in Table 7.

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Table 7 – Filter Bandwidth Control Codes

Code	Filter Control Codes
0x00	Disable Filter
0x01	IIR Filter -3 dB at 25Hz
0x02	IIR Filter -3 dB at 50Hz (Default)
0x03	IIR Filter -3 dB at 75Hz
0x04	IIR Filter -3 dB at 100Hz
0x05	IIR Filter -3 dB at 10Hz
0x06	IIR Filter -3 dB at 150Hz
0x07	IIR Filter -3 dB at 200Hz

4.4.3 Select Sensors 0x0205

The *Select Sensors* message provides a means to configure and save the contents of the IMU data messages transmitted.

The *Select Sensors* function codes define the function to be performed on the device’s message format. The associated codes and functions for the MS-IMU3050 are listed in Table 8 below.

Table 8 – Select Sensors Function Codes

Code	Select Sensors Function
0x01	Use new settings.
0x02	Request current settings.
0x03	Save current settings as startup settings.
0x04	Load saved startup settings.
0x05	Reset to default settings.

Table 9 lists the codes for the available measurements to be selected.

Table 9 – Select Sensors Options

Code	Select Sensors Options
0x81	Scaled Acceleration Vector in <i>g</i>
0x82	Scaled Angular Rate Vector in deg/sec
0x83	Scaled Magnetic Field Vector in gauss
0x84	Delta Theta Vector in Radians
0x85	Delta Velocity Vector in m/s
0x87	Scaled Temperature in Celsius
0x88	GPS Correlated Time

For each measurement selected the associated data code must be provided. When a Select Sensor message requests a sensor option that doesn’t exist in the IMU (magnetometer or pressure), a NACK message will be returned.

See the MS-CIP at memsense.com under the MS-IMU3050 product page for more details regarding Select Sensors.

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4.4.4 Config Accel Range 0x0207

The MS-IMU3050 supports the configuration of accelerometer dynamic ranges. The following configuration information details the options available and associated codes used in the communication protocol.

The *Config Accel Range* message provides a means for configuring and saving the triaxial accelerometer dynamic range options.

The *Config Accel Range Function* allows the configuration to be used, queried, saved, loaded from startup settings, and reset to defaults. Table 10 details the associated codes and functions.

Table 10 –Config Accel Range Function Codes

Code	Configure Accel Range Function Codes
0x01	Use new settings.
0x02	Request current settings.
0x03	Save current settings as startup settings.
0x04	Load saved startup settings.
0x05	Reset to default settings.

The *Accel Range* codes allow the dynamic range of the accelerometer to be changed to one of the 3 supported ranges and effect all three axes of the sensor. The options for the accelerometer dynamic range are controlled in the *Accel Range Codes* listed in Table 11.

Table 11 – Accel Range Codes

Code	Accel Range Codes	IMU Model Number
0x00	Accelerometer range $\pm 2 g$	MS-IMU3050M MS-IMU3050
0x01	Accelerometer range $\pm 4 g$	MS-IMU3050M MS-IMU3050
0x02	Accelerometer range $\pm 8 g$	MS-IMU3050M MS-IMU3050
0x03	Accelerometer range $\pm 10 g$	MS-IMU3050ME MS-IMU3050E
0x05	Accelerometer range $\pm 20 g$	MS-IMU3050ME MS-IMU3050E
0x06	Accelerometer range $\pm 40 g$	MS-IMU3050ME MS-IMU3050E

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4.4.1 Config Gyro Range 0x0208

The MS-IMU3050 supports the configuration of gyroscope dynamic ranges. The following configuration information details the options available and associated codes used in the communication protocol.

The *Config Gyro Range* message provides a means for configuring and saving the triaxial gyroscope dynamic range options. The *Config Gyro Range Function* allows the configuration to be used, queried, saved, loaded from startup settings, and reset to defaults. Table 12 details the associated codes and functions.

Table 12 – Config Gyro Range Function Codes

Code	Configure Gyro Range Function Codes
0X01	Use new settings.
0x02	Request current settings.
0x03	Save current settings as startup settings.
0x04	Load saved startup settings.
0x05	Reset to default settings.

The *Gyro Range* codes allow the dynamic range of the gyroscope to be changed to 1 of the 5 supported ranges and effect all 3 axes of the sensor. The options for the gyroscope dynamic range are controlled in the *Gyro Range Codes*. The MS-IMU3050 codes are listed in Table 13.

Table 13 – MS-IMU3050 Gyro Range Codes

Code	Gyro Range Codes
0x06	Gyroscope range ± 75 °/s
0x07	Gyroscope range ± 200 °/s
0x03	Gyroscope range ± 480 °/s (Default)
0x04	Gyroscope range ± 960 °/s
0x05	Gyroscope range ± 1920 °/s

5.0 OPTIONS

5.1 Part Numbering

The standard part numbers, sensor ranges and associated ECCNs for the MS-IMU3050 are listed in the table below.

Table 14 - Standard part numbers

Model Number	Part Number	Maximum Ranges				ECCNs
		Accel (g)	Aux Accel (g)	Rate (°/s)	Mag (gauss)	
MS-IMU3050M	MP00067-001 ¹	±8	None	±1920	2	7A003
MS-IMU3050	MP00067-002 ¹	±8	None	±1920	None	7A003
MS-IMU3050MHH	MP00067-007 ²	±40	None	±1920	2	7A003
MS-IMU3050HH	MP00067-008 ²	±40	None	±1920	None	7A003

Note 1: The ±8g range is configurable to ±2g, ±4g or ±8g.

Note 2: The ±40g range is configurable to ±10g, ±20g or ±40g.

5.2 MS-IMU3050 Accessories

Accessories available for the MS-IMU3050 include interface cables, a USB data acquisition module (USB-DAQ) and the MS-IMU3050 configuration software. The accessories allow an end user to rapidly connect, configure and collect evaluation data with the MS-IMU3050. The software provides valuable tools used in developing communications with the IMU. Table 15 provides the part number details.

Table 15 - Accessories part numbers

Model Number	Part Number	Description
C30X0-G10F-H6F-36	MP00063-001	MS-IMU30X0 36-inch Development Interface Cable
C30X0-G10F-PTL-08	MP00063-003	MS-IMU30X0 8-inch Unterminated Interface Cable
C30X0-G10F-PTL-12	MP00063-004	MS-IMU30X0 12-inch Unterminated Interface Cable
USB-DAQ-EXT	MP00009-002	MS-IMU3050 Specific USB Data Acquisition Module External Power
MS-CIP-EVAL		MS-IMU30X0 Configuration Software

5.3 MS-IMU3050 Development Kit Part Numbering

Development kits available for the MS-IMU3050 are listed in Table 16 below and include a 36-inch development cable, a 12-inch pigtail cable, a USB data acquisition module, the MS-IMU3050 configuration software and the MS-IMU3050 model indicated in the table.

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Table 16 – Development kit part numbers

Model Number	Part Number	Description	ECCN
MS-IMU3050M Dev Kit	MP00073-001	MP00067-001, MP00063-001, MP00063-004, MP0009-002 and MS-CIP Eval	7A003
MS-IMU3050 Dev Kit	MP00073-002	MP00067-002, MP00063-001, MP00063-004, MP0009-002 and MS-CIP Eval	7A003
MS-IMU3050MHH Dev Kit	MP00073-007	MP00067-007, MP00063-001, MP00063-004, MP0009-002 and MS-CIP Eval	7A003
MS-IMU3050HH Dev Kit	MP00073-008	MP00067-008, MP00063-001, MP00063-004, MP0009-002 and MS-CIP Eval	7A003

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Document Change History

REV	STATUS	DESCRIPTION	DATE
Prelim	Obsolete	Specification preliminary release.	2-12-2018
A	Obsolete	Specification release. Figure 3 Connector Pinout updated to correct version and pinout. Updated Options section.	9-3-2018
B	Obsolete	Updated Mechanical drawing. Added export ECCNs to the development kit part number table.	10-7-2018
C	Released	Remove export version from part numbers due to all versions being export controlled.	11-5-2018

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