MEMSENSE
Customer Focused Inertial Solutions

MS IMU 3020

PRODUCT SPECIFICATION & USER GUIDE

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MEMSENSE.COM

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MS IMU 3020

MEMSENSE

1.0 OVERVIEW

The MS-IMU3020 inertial measurement unit delivers market leading price to performance in an ultra-compact aluminum package. The gyro bias instability of 1 °/h and accelerometer bias instability of 14.8 µ*g* supply ample inertial performance to support a range of applications from UAS navigation and control to pipeline inspection. User configurable options allow the IMU to be tuned to your application with configurable bandwidth, sample rate, gyro ranges, 1 PPS input and other measurement parameters. Streamline your global operation and improve performance with the MS-IMU3020 that requires no export license. The IMU provides all these features in a package that only measures 1.1 x 1.1 x 0.4 inches with a mass of only 20 grams. The MS-IMU3020's combination of inertial performance, size, configurability, and value surpasses all IMUs in the market.

2.0 INERTIAL SPECIFICATIONS

Table 1 - Specifications

ACCELERATION	TYPICAL			MAX	UNITS	NOTES
Dynamic Range				± 15	g	Note 1
Bias Instability		14.8			µ*g*	Typical
Offset		±1.2		±7.0	*mg*	
Nonlinearity		±0.3			% of FS	Typical
Velocity Random Walk		0.078			m/s/h $^{-1/2}$	Typical
Noise Density		160			µ*g*/Hz$^{-1/2}$	Typical
Vibration Rectification Coef.		482.5			µ*g*/grms^2	Typical, Note 2
Bandwidth		50			Hz	-3dB point, Note 3
ANGULAR RATE					**UNITS**	**NOTES**
Dynamic Range	±120	±240	±480	±960	±1920	°/s	Minimum, Note 4
Bias Instability	1.06	1.06	1.06	1.06	1.31	°/h	Typical
Offset	20.5 100.0	19.0 100.0	16.6 100.0	19.3 120.0	25.3 200.0	°/h	Typical Max
Nonlinearity	0.05	0.05	0.05	0.05	0.05	% of FS	Typical, Note 5
Angle Random Walk	0.22	0.22	0.22	0.22	0.22	°/h $^{-1/2}$	Typical
Noise Density	0.007	0.007	0.006	0.006	0.006	°/s /Hz$^{-1/2}$	Typical
Bandwidth	50 230	50 230	50 230	50 230	50 230	Hz	Typical Max -3dB point, Note 3

1. The MS-IMU3020 will not output greater than ± 15 g.
2. Parameter derived with 6 g rms random vibration input 30Hz to 2000Hz.
3. Bandwidth is configurable see section 4.4.2 Configure Filter.
4. Angular rate dynamic range is configurable see section 4.4.5 Config Gyro Range.
5. Nonlinearity is specified from -30 to 85°C at angular rate of ± 450 °/s.

MAGNETIC FIELD	NOTE 6	UNITS	NOTES
Dynamic Range	± 1.9	gauss	Minimum
Offset	± 0.005	gauss	Typical
Noise Density	79.2	µgauss	Typical
Bandwidth	50	Hz	-3dB point

DEVICE TEMPERATURE		UNITS	NOTES
Temperature Error	± 1.5	°C	Maximum

PRESSURE	NOTE 7	UNITS	NOTES
Range	26 to 1260	mBar	

1 PULSE PER SECOND INPUT		UNITS	NOTES
Maximum Voltage Low Level Input	0.9	V	Maximum
Minimum Voltage High Level Input	2.1	V	Minimum
Trigger Edge	Rising		

EXTERNAL TRIGGER INPUT		UNITS	NOTES
Maximum Voltage Low Level Input	0.9	V	Maximum
Minimum Voltage High Level Input	2.1	V	Minimum
Minimum Pulse Width	1.0	µs	Minimum

TIME OF VALIDITY OUTPUT		UNITS	NOTES
Maximum Voltage Low Level Output	0.4	V	Maximum
Minimum Voltage High Level Output	2.6	V	Minimum
Maximum Rise and Fall Time	30	ns	Maximum

PHYSICAL		UNITS	NOTES
Dimensions	1.100 × 1.100 × 0.424	in.	(L x W x H)
Mass	20	grams	

OPERATIONAL		UNITS	NOTES
Supply Voltage	4.9 to 30.0	VDC	
Supply Power	0.65	W	Typical
Operating Temperature	-40 to 85	°C	
MTBF	1,597,889	hours	operating hours, 217 Plus
Interface Connector	Harwin G125-MS11005L MS11005L		10-pin
Mating Connector	Harwin G125-2041096L0		10-pin
Connector Compatibility	MS-IMU3030 and MS-IMU3050		
Protocol Compatibility	MS-IMU3030 and MS-IMU3050		

ABSOLUTE MAXIMUM RATINGS	NOTE 8	UNITS	NOTES
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	

6. MS-IMU3020M and MS-IMU3020MP only.

7. MS-IMU3020P and MS-IMU3020MP only.

8. Absolute Maximum Ratings list device survivability specifications and are non-operational.

9. All values labeled "Typical" are at 25°C, 0 °/s, and the mean of the device population unless otherwise noted.

Accel Root Allan Variance

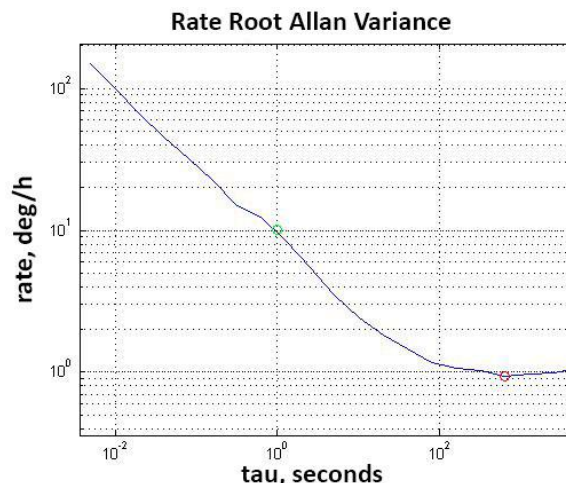### Rate Root Allan Variance

3.0   MECHANICAL

3.1   Dimensions

The MS-IMU3020 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 IMU's 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-IMU3020 product page.

0.950
0.125
LOCATION
Ø 1/16 DOWEL PIN
0.110
0.409
0.950
0.200
0.079
Ø 0.150
0.125
MOUNTING
2-56 Captive Socket Head Cap Screw
18-8 Stainless Steel, NOTE 1

0.42
#0-80
0.100
2 places
0.560
1.100
0.079
0.097

1.100

0.0010 Relative to All Mounting Surfaces

Note 1: Suggested Maximum Torque: 2.5 in-lbs
While this value is provided from reliable sources, there are many variables that will effect this value and the use of this information is at the sole risk of the user.
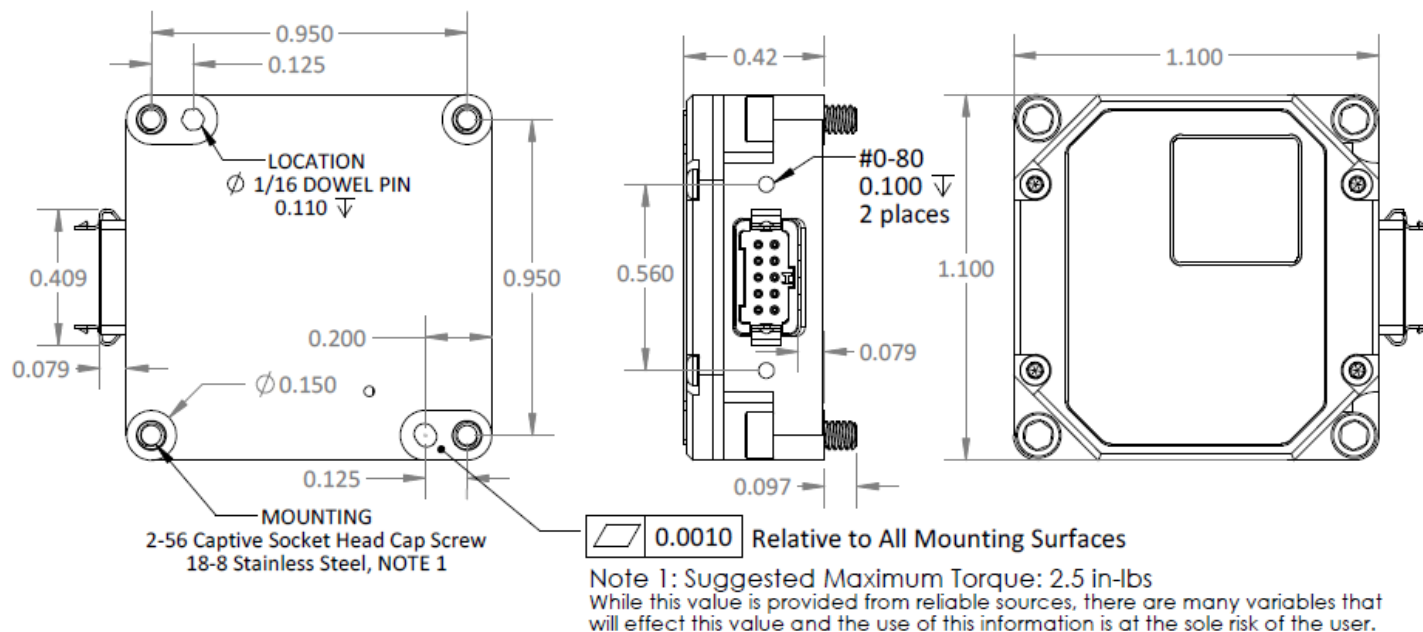
Figure 1 - Physical dimensions (inches)

3.2   Coordinate System

The coordinate system for the MS-IMU3020 follows the right-hand rule convention.   As an example, with the inertial measurement unit 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-IMU3020 coordinate system

4.0   COMMUNICATIONS

4.1   Default Settings

The MS-IMU3020 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
Start Bit	1
Stop Bit	1
Data Bits	8
Parity	None

4.2   Hardware Interface

The MS-IMU3020 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 electrical interface is further detailed in the figure and table below as well as sections 4.2.1 through 4.2.3.
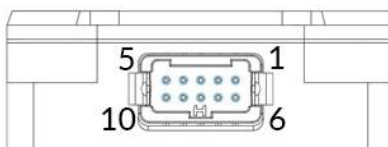
Figure 3 – MS-IMU3020 electrical interface connector

Table 3 – MS-IMU3020 Signal Interface

PIN	SIGNAL NAME	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

Information provided herein is considered accurate however is not guaranteed. Memsense reserves the right to change specifications at any time, without notice.

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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 4.1.2 External Trigger Input for TOV output with external trigger enabled.
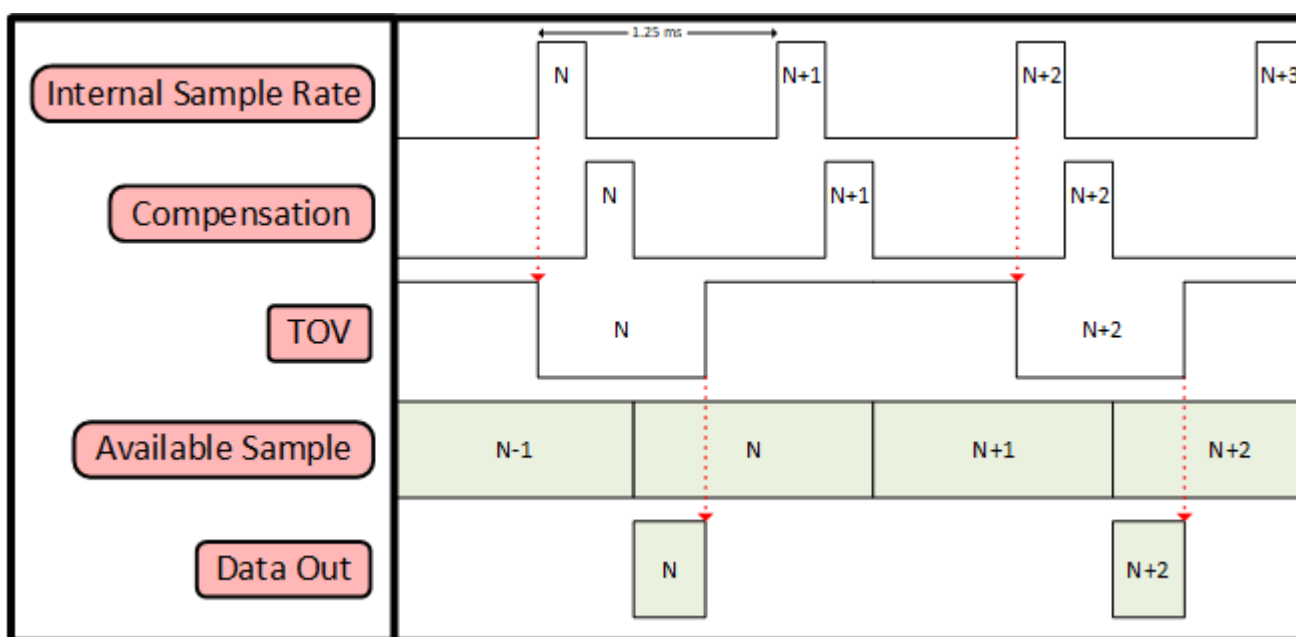

Figure 4 – TOV timing diagram with output sample rate at decimation of 2.

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 rising 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.
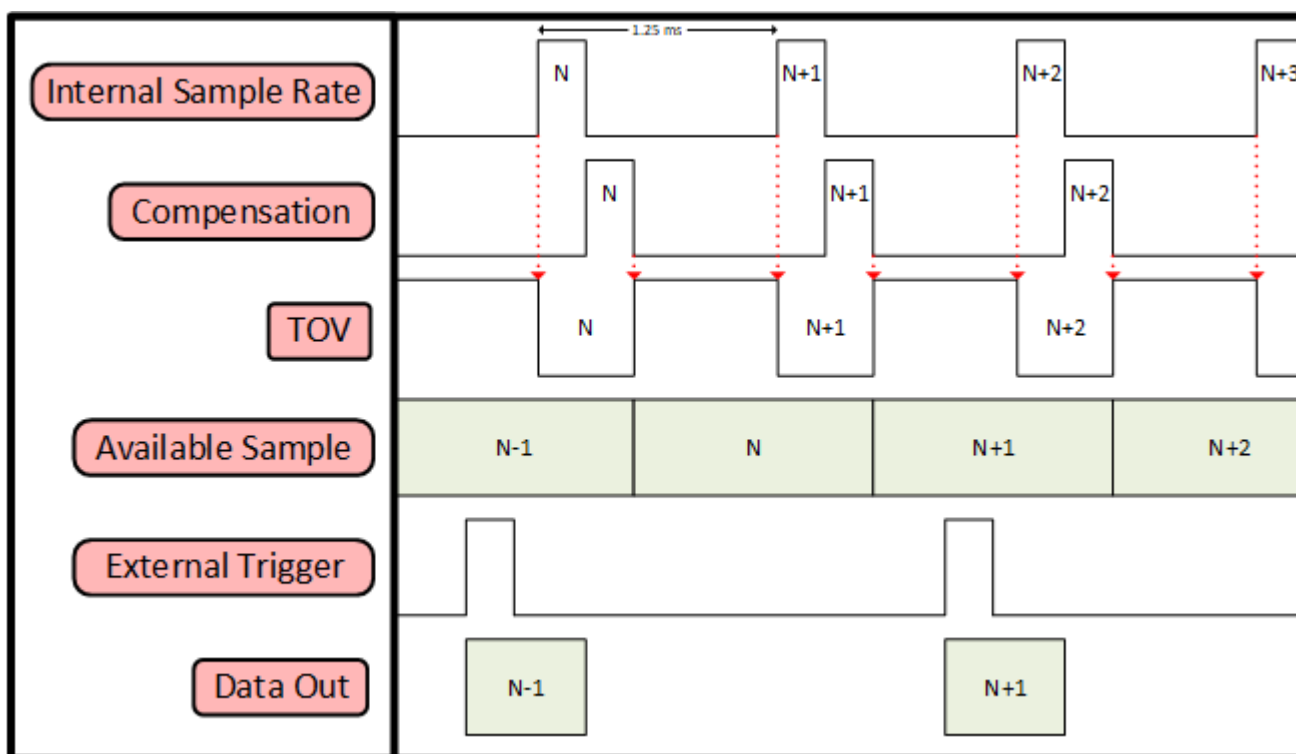
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Figure 5 – External Trigger timing diagram.

4.2.3 1 Pulse Per Second Input

The *1 Pulse Per Second Input (1 PPS)*, pin 3, provides a means to synchronize the IMU's sample transmission with a GPS receiver's 1 pulse per second output. A Rising Edge signal on the 1 PPS input time initiates a time reset to the nearest second.

4.3 Internal Sample Rate

The MS-IMU3020 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-IMU3020 product page at memsense.com. The following information provides an overview and contains MS-IMU3020 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-IMU3020.

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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

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 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-IMU3020 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-IMU3020 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-IMU3020. Filter cutoff options for the MS-IMU3020 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-IMU3020 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 *g*
0x82	Scaled Angular Rate Vector in °/sec
0x83	Scaled Magnetic Field Vector in gauss
0x84	Delta Theta Vector in Radians
0x85	Delta Velocity Vector in m/s
0x86	Scaled Pressure in milliBar
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.

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See the MS-CIP at memsense.com under the MS-IMU3020 product page for more details regarding Select Sensors.

4.4.4 Config Gyro Range 0X0208

The MS-IMU3020 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 10 details the associated codes and functions.

Table 10 – Config Gyro Range Function Codes

CODE	CONFIG 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-IMU3020 codes are listed in Table 11.

Table 11 – MS-IMU3020 Gyro Range Codes

CODE	GYRO RANGE CODES
0x01	Gyroscope range: ±120 °/s
0x02	Gyroscope range: ±240 °/s
0x03	Gyroscope range: ±480 °/s (Default)
0x04	Gyroscope range: ±960 °/s
0x05	Gyroscope range: ±1920 °/s

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5.0   OPTIONS

5.1   Part Numbering

The standard part numbers, sensor ranges and associated ECCNs for the MS-IMU3020 are listed in the table below. All versions of the MS-IMU3020 have an Export Control Classification Number (ECCN) of No License Required (NLR).

Table 12 - Standard part numbers

| MODEL NUMBER | PART NUMBER | MAXIMUM RANGES | | | | |
		ACCEL (g)	RATE (°/s)	MAGNETOMETER (gauss)	PRESSURE SENSOR (mBar)	ECCNs
MS-IMU3020	MP00062-005	±15	±1920	None	None	NLR
MS-IMU3020P	MP00062-007	±15	±1920	None	1260	NLR
MS-IMU3020M	MP00062-008	±15	±1920	±1.9	None	NLR
MS-IMU3020MP	MP00062-003	±15	±1920	±1.9	1260	NLR

5.2   MS-IMU3020 Accessories

Accessories available for the MS-IMU3020 include interface cables, a USB data acquisition module (USB-DAQ) and the MS-IMU3020 configuration software. The accessories allow an end user to rapidly connect, configure and collect evaluation data with the MS-IMU3020. The software provides valuable tools used in developing communications with the IMU. The table below provides the accessory part number details.

Table 13 - Accessories part numbers

MODEL NUMBER	PART NUMBER	DESCRIPTION
C30X0-G10F-H6F-36	MP00063-001	MS-IMU3020 36-inch Development Interface Cable
C30X0-G10F-PTL-08	MP00063-003	MS-IMU3020 8-inch Unterminated Interface Cable
C30X0-G10F-PTL-12	MP00063-004	MS-IMU3020 12-inch Unterminated Interface Cable
USB-DAQ	MP00009-004	MS-IMU3020 Specific USB Data Acquisition Module
MS-CIP-EVAL	N/A	MS-IMU3020 Configuration Software

5.3   MS-IMU3020 Development Kit Part Numbering

Development kits available for the MS-IMU3020 are listed in Table 14 below and include a 36-inch development cable, a 12-inch pigtail cable, a USB data acquisition module, the MS-IMU3020 configuration software and the MS-IMU3020 model indicated in the table.

Table 14 – Development kit part numbers

MODEL NUMBER	PART NUMBER	DESCRIPTION	ECCN
MS-IMU3020 Dev Kit	MP00068-001	MP00062-005, MP00063-001, MP00063-004, MP0009-004 and MS-CIP Eval	NLR
MS-IMU3020M Dev Kit	MP00068-002	MP00062-008, MP00063-001, MP00063-004, MP0009-004 and MS-CIP Eval	NLR
MS-IMU3020MP Dev Kit	MP00068-003	MP00062-003, MP00063-001, MP00063-004, MP0009-004 and MS-CIP Eval	NLR
MS-IMU3020P Dev Kit	MP00068-004	MP00062-007, MP00063-001, MP00063-004, MP0009-004 and MS-CIP Eval	NLR

6.0 DOCUMENT REVISION HISTORY

REV	STATUS	DESCRIPTION	DATE
Prelim	Obsolete	Specification preliminary release.	12-29-2015
A	Obsolete	Specification initial release.	2-2-2016
B	Obsolete	Removed MS-IMU3020E, all MS-IMU3020s are now NLR. Changed Note 1, 3 and 4 for Table 1. Added Note 6 and 7 for Table 1. Added Section 4.1.1 Time of Validity Output. Added Section 4.1.2 External Trigger Input. Removed Gyro Config Table for MS-IMU3020E. Updated Table 10 Standard Part Numbers.	6-8-2016
C	Obsolete	Updated Accel Bias Instability and Velocity Random Walk Updated Accel Bias Instability and Velocity Random Walk Added 200Hz Filter Bandwidth Code in Table 5	10-14-2016
D	Obsolete	Added Default Settings Section to Communications Added IMU Sample Rate Configure to Communications Added Defaults to applicable tables	12-14-2016
E	Obsolete	Updated Specification Table	4-6-2017
F	Obsolete	Updated formatting. Deleted references to Revision A product. Added vibration sensitivity specifications.	9-1-2017
G	Obsolete	Added development kit part numbers and removed MP00063-002 18-inch development cable.	1-8-2018
H	Obsolete	Added 150Hz sample rate to Table 7 and corrected sample rate codes for 200Hz and 150Hz.	4-13-2018
J	Obsolete	Added 1PPS Input voltage level specifications. Added UART bit and parity specifications. RS-422 output voltage specifications.	6-13-2018
K	Obsolete	Updated mechanical drawing to include connector screw holes. Updated product and document revision. Moved revision table to the document end.	10-5-2018
L	Obsolete	Add product revision table. Changed product released revision.	10-22-2019
M	Obsolete	Changed product released revision.	10-22-2019
N	Obsolete	Changed product released revision.	7-10-2020
P	Obsolete	Corrected error pertaining to external trigger edge. External trigger is rising edge activation. Two associated figures were updated.	3-9-2021
Q	Released	Updated specification table.	3-29-2021

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7.0   PRODUCT REVISION HISTORY

REV	STATUS	DESCRIPTION	DATE
A	Released	Product initial release.	2-2-2016
B	Released	Added Time of Validity and External Trigger features.	6-6-2016
C	Released	Added internal gaskets for the pressure sensor and connector.	10-30-2017
D	Released	IMU housing revision to facilitate an interface cable assembly with a back shell incorporating two 0-80 screw attachments.	2-28-2018
E	Released	Captive screw change from brass to 18-8 stainless steel.	4-1-2019
F	Released	Improved gyroscope cross sensitivity.	10-22-2019
G	Released	IMU housing alignment pin hole geometry changed for increased alignment repeatability.	11-1-2019
H	Current	Gasket changed to polypropylene material.	7-10-2020