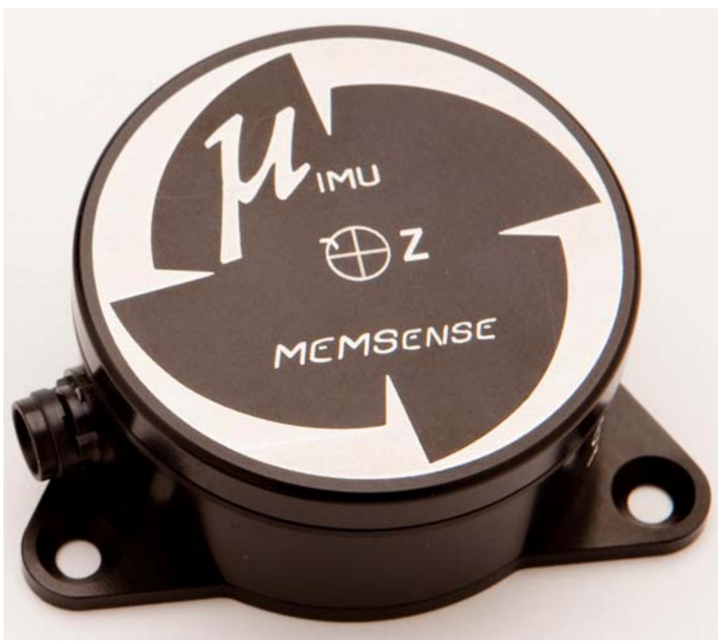
MICRO IMU
Product Specification User's Guide

Document Number: PSD-0820
Document Revision: F



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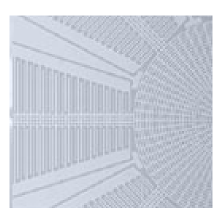

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Document Number:	Release / Revision	Release / Revision Date:
PSD-0820	**F**	**September 27, 2011**

Document Owner:

Design Engineering

MEMSENSE

Document Change History

Rev	Status	Description	Date
2.12	Obsolete		12/15/2008
A	Obsolete	Created from PSD-0820_Rev-2.12. Changed to the new MEMSense document format	2/4/2009
B	Obsolete	Updated Figure 1 to change inaccurate voltage input description. Updated table to address possible damage to an 8.3V USB DAQ.	8/10/2009
C	Obsolete	Added the USB DAQ Options section (5.2) and Table 5 – USB DAQ Options. Updated Table 5 (old) to table 6 – Specifications – clarified optional 12V USB DAQ. Updated footer Revs. Removed Template Change History page.	9/29/09
D	Obsolete	Updated uIMU photo on page i. Corrected footers. Added Model Numbers to Table 5. Corrected formatting in Table 6 to make superscript legible.	2/3/2010
E	Obsolete	**Added 150 deg/sec gyro specifications.**	**3/18/2011**
F	Released	**Updated the USB DAQ section.**	**9/27/2011**

TABLE OF CONTENTS

1.0 Purpose

1.1 The Micro Inertial Measurement Unit

This manual documents the features and use of the µIMU series of products. The µIMU provides serial digital outputs of 3D acceleration, 3D rate of turn (rotational), and 3D magnetic field data. The µIMU provides digital outputs via the RS422 protocol while custom algorithms provide high performance, temperature compensated, 3 axis data in real time (see Section 5.1 for part numbering specifications).

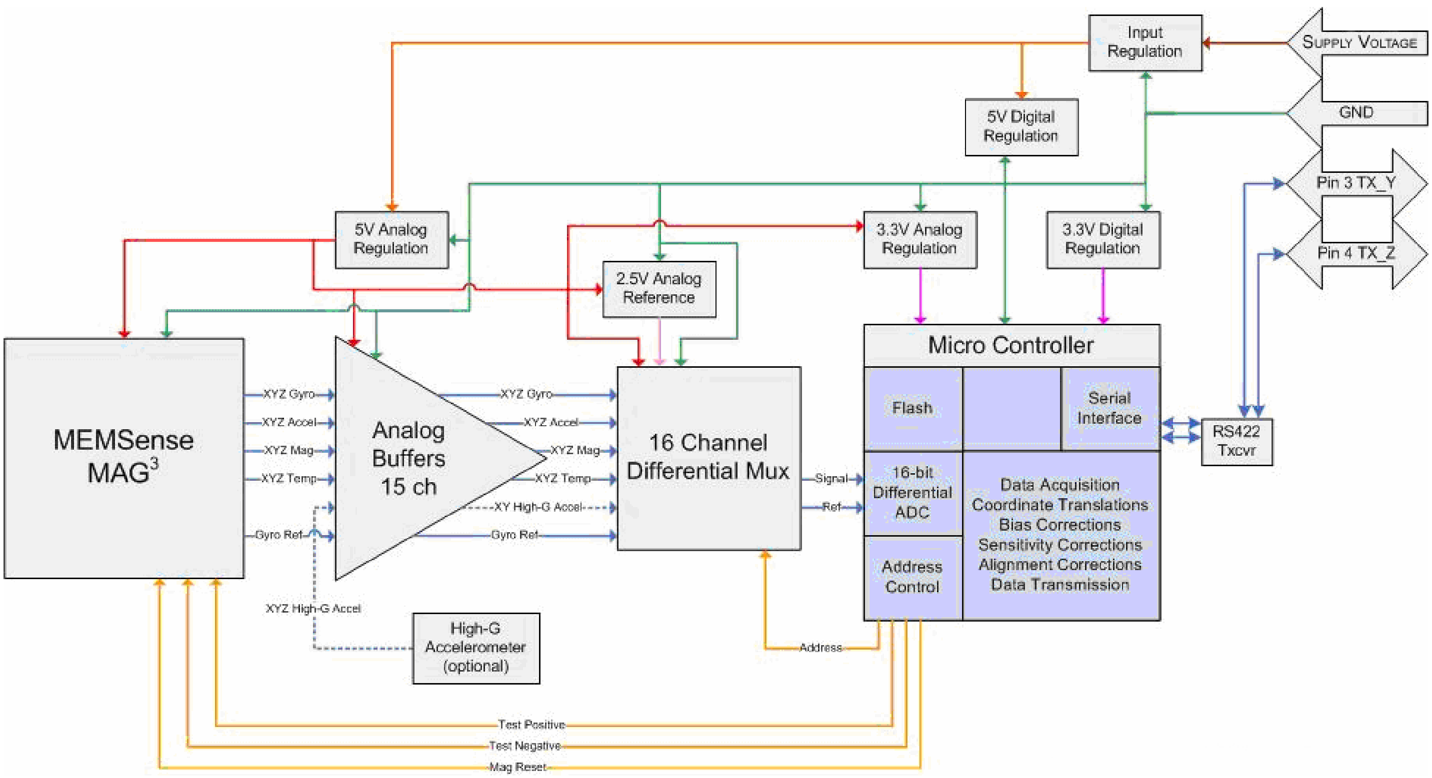

Figure 1 - µIMU Functional Block Diagram

2.0 Communications

2.1 Commands

The µIMU does not currently offer a command structure or API that allows modification of device characteristics at runtime.

2.2 Sample Format

The µIMU will begin transmitting data once power is applied to the device. Data samples are formatted as shown in Tables 1 and 2. Each data channel is represented by a signed (2's complement) 16-bit integer that must be converted to its corresponding engineering unit before use (see Section 2.3). An individual data packet is collectively referred to as a *sample*.

Table 1
Sample byte order

Byte	Element
0	Synchronization byte (FF)
1	Synchronization byte (FF)
2	Synchronization byte (FF)
3	Synchronization byte (FF)
4	Message size
5	Device ID
6	Message ID
7	Timer (MSB)
8	Timer (LSB)
9-12	Reserved
13	Gyro X (MSB)
14	Gyro X (LSB)
15	Gyro Y (MSB)
16	Gyro Y (LSB)
17	Gyro Z (MSB)
18	Gyro Z (LSB)
19	Accelerometer X (2/5/10g) (MSB)
20	Accelerometer X (2/5/10g) (LSB)
21	Accelerometer Y (2/5/10g) (MSB)
22	Accelerometer Y (2/5/10g) (LSB)
23	Accelerometer Z (2/5/10g) (MSB)
24	Accelerometer Z (2/5/10g) (LSB)
25	Magnetometer X (MSB)
26	Magnetometer X (LSB)
27	Magnetometer Y (MSB)
28	Magnetometer Y (LSB)
29	Magnetometer Z (MSB)
30	Magnetometer Z (LSB)
31	Temperature (MSB)
32	Temperature (LSB)
33	8-bit Checksum

Table 2
Sample byte order
(including optional high g accelerometer)

Byte	Element
0	Synchronization byte (FF)
1	Synchronization byte (FF)
2	Synchronization byte (FF)
3	Synchronization byte (FF)
4	Message size
5	Device ID
6	Message ID
7	Timer (MSB)
8	Timer (LSB)
9-12	Reserved
13	Gyro X (MSB)
14	Gyro X (LSB)
15	Gyro Y (MSB)
16	Gyro Y (LSB)
17	Gyro Z (MSB)
18	Gyro Z (LSB)
19	Accelerometer X (2/5/10g) (MSB)
20	Accelerometer X (2/5/10g) (LSB)
21	Accelerometer Y (2/5/10g) (MSB)
22	Accelerometer Y (2/5/10g) (LSB)
23	Accelerometer Z (2/5/10g) (MSB)
24	Accelerometer Z (2/5/10g) (LSB)
25	Magnetometer X (MSB)
26	Magnetometer X (LSB)
27	Magnetometer Y (MSB)
28	Magnetometer Y (LSB)
29	Magnetometer Z (MSB)
30	Magnetometer Z (LSB)
31	Accelerometer X (35/50g) (MSB)
32	Accelerometer X (35/50g) (LSB)
33	Accelerometer Y (35/50g) (MSB)
34	Accelerometer Y (35/50g) (LSB)
35	Accelerometer Z (35/50g) (MSB)
36	Accelerometer Z (35/50g) (LSB)
37	Temperature (MSB)
38	Temperature (LSB)
39	8-bit Checksum

Graphically, the sample has the format shown in Figure 2:

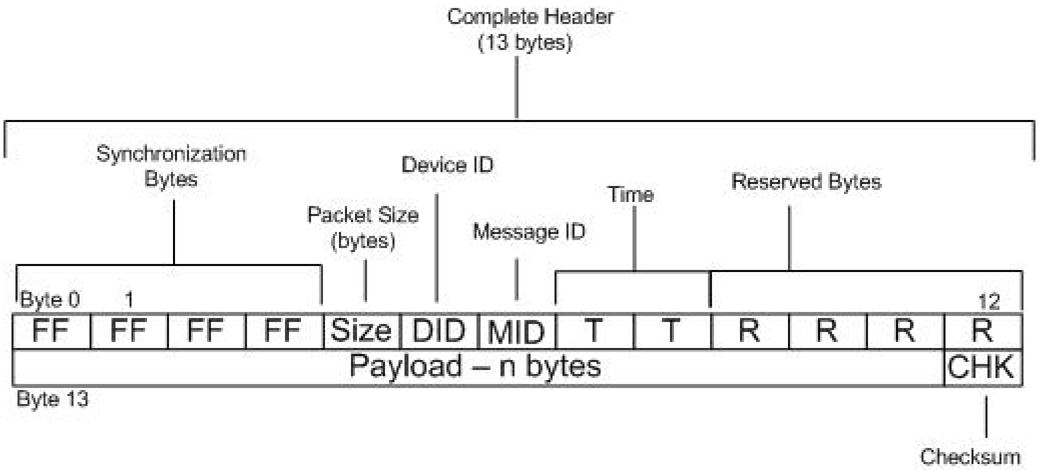

Figure 2 - Sample structure

All samples begin with four (4) synchronization bytes, where each byte is encoded with FF hex. Synchronization bytes aid in the identification of the beginning of samples as they arrive from the device. There are two cases in which synchronization is necessary: 1) initial synchronization of data once the device is powered and 2) re-synchronization if data is lost or errors are encountered. The complete structure of a sample is as follows (*Note: all byte offsets are zero (0) based*):

1. Synchronization bytes: bytes 0-3 with each byte encoded as 0xFF hex.
2. Packet size: size, in bytes, of entire data packet, including complete header.
3. Device ID.
4. Message ID: type of message. Currently, only data messages are transmitted by the device with MID 0x14 hex (20 decimal).
5. Sample Timer: bytes 7 (MSB) and 8 (LSB) when combined represent a 16-bit timer value of the time at which the ADC started the conversion for the X Gyro with a scale of 2.1701×10^{-6} seconds/count.
6. Reserved bytes: four (4) bytes are reserved for internal/future use.
7. Payload: payload always starts at byte 13. The payload size can be calculated as follows:

   payload_size = message_size – 13(header) – 1(Checksum byte)

8. Checksum byte: 8-bit checksum byte.
   a. Sum sample contents (header + payload). DO NOT include the checksum byte.
   b. The summed value should equal the checksum if the message is valid.
   c. *Note: If greater precision (larger than 8-bit) addition is used to calculate the checksum, the checksum will be the remainder of a divide by 256*.

2.3 Measurement

Accelerometer, gyro and magnetometer data is temperature compensated on the µIMU. The payload element of the data packet contains accelerometer, gyro and magnetometer samples, which must be converted to values that represent usable data (e.g. rotational rate, G-force, gauss). The data is transmitted as signed (2's complement) 16-bit integers. The following function must be used for conversion of sample values.

Equation 1: result = *raw_payload_value* x *digital_sensitivity*

where result is the converted value in the appropriate units (e.g. deg/sec), raw_payload_value is the raw component-specific value from the payload (e.g. accelerometer X), and Digital_Sensitivity is the sensitivity expressed in engineering unit per bits. Digital sensitivity values are listed in the Specification Table 5 on page 9. (NOTE: You must use the value specific to the dynamic range of the device you have purchased). For example, if you have purchased a ±300 deg/s, ±2 G µIMU, the corresponding equations for the X component would be:

$$value\_x = raw\_payload\_value\_x_{gyro} \times 1.3733 \times 10^{-2}\ {}^{\circ}/s\ /bit$$

$$value\_x = raw\_payload\_value\_x_{accel} \times 9.1553 \times 10^{-5}\ G/bit$$

where raw_payload_value_x is taken from the sample payload corresponding to the x-components of the gyro and accelerometer, respectively. The resulting values have units of degrees/sec and G's, respectively.

In the cases where a custom dynamic range has been ordered, the digital sensitivity can be found by the following equation:

Equation 2: $digital\_sensitivity = dynamic\_range \times 4.57764 \times 10^{-5}$

where digital sensitivity is expressed in engineering units per bit and dynamic range is the unipolar range for the specific sensor axis (e.g. ±0075 º/s then 75 º/s should be used for the dynamic range in Equation 3).

Although the sensor data is temperature compensated, a customer's application may require the use of temperature information, therefore a temperature is provided. The temperature data provided in the payload requires a different conversion process. The data is transmitted as signed (2's complement) 16-bit integers. The following function must be used for conversion of temperature sample values:

[**Equation 3:** $result\_deg\_C = (raw\_payload\_value\_x_{temperature} \times digital\_sensitivity) + 25$]

where result is the converted value in degrees Celsius, raw_payload_value_temp is the raw value from the payload in bits and the digital sensitivity is the temperature sensitivity expressed in degrees C per bit (digital sensitivities are listed on page 9 in the Specification Table).

3.0 Mechanical

3.1 Dimensions

The µIMU is available in a custom package measuring 2.276 in. diameter × 0.956 in. height with front and back mounting options as shown in Figure 3 (below).

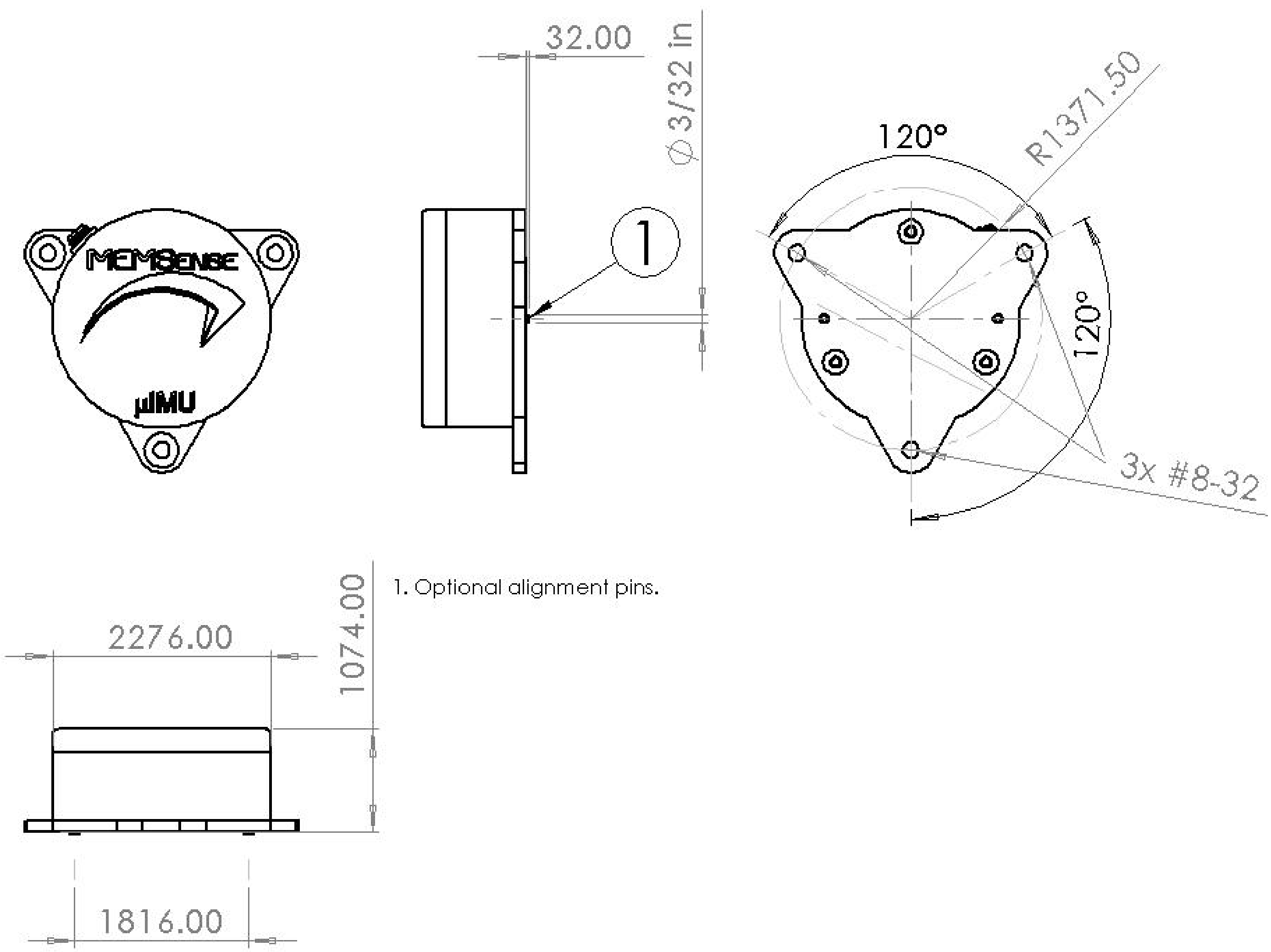

Figure 3 - Front mount
(dimensions in mils unless noted)

3.2 Coordinate System

The accelerometers produce a positive output proportional to the inertial resultant of the uIMU body acceleration. The gyros output a positive rate when the uIMU experiences a counterclockwise rotation about the positive acceleration axis. The coordinate system of the device is as shown in Figure 4 (below).

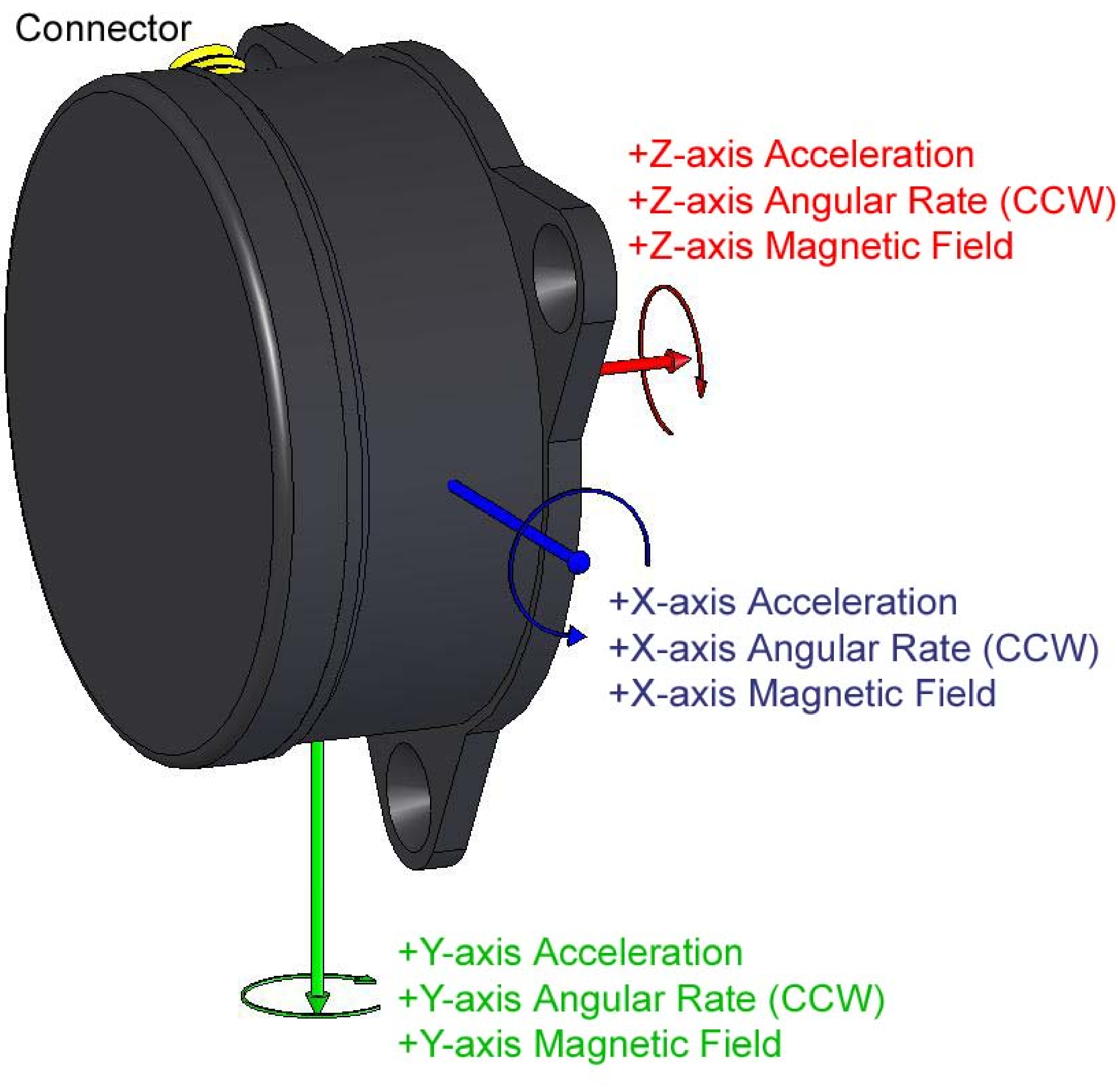

Figure 4 - µIMU coordinate system

4.0 Hardware

4.1 Connections

The µIMU interface connector is a Hirose HR-30 series miniature waterproof plastic connector. This connector provides excellent protection against the environment, as well as an IP67 protection rating. In addition, it contains a built-in lock/release mechanism, is lightweight and corrosion resistant.

The µIMU does not ship with a cable; the user must provide a cable with adequate shielding to provide for EMI protection, and configured to match the connector pin function description as identified in Table 3 (below).

4.2 Pin Function Description

Table 3 (below) shows the pin function description for the Hirose connector interface.

Table 3 - Hirose pin functions
(*Note: Mates with HR30-6P-6S female solder type plug*)

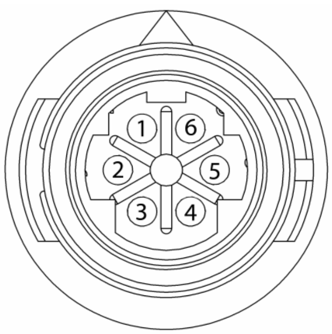

Figure 5– HR30-6R-6P

Port No.	RS485
1	Reserved
2	Vdd
3	RS485_TX_Y
4	RS485_TX_Z
5	Gnd
6	Reserved

4.3 RS422 Connection Description

The µIMU RS422 connection is factory configured to 115200 Baud. The RS422 connection is configured as an 8-bit UART with one start bit, eight data bits, and one stop bit. Data is sent from the µIMU via the YZ differential driver pair and should be terminated with a 120 ohm resistor.

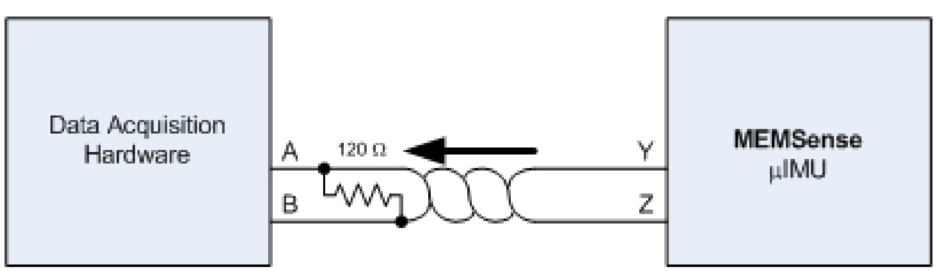

Figure 6 - RS422 direct connection diagram

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5.0 Electrical Specifications and Options

5.1 Part Numbers

Table 4 - Standard Part Numbers

Part	Accel.(g)	Angular Rate (^{o}/s)	Bandwidth (Hz.)	Optional Accel. (g)
IM02-0300C050T00	±2	±300	50	None
IM02-0300C050T35	±2	±300	50	±35
IM02-0300C050T50	±2	±300	50	±50
IM05-0300C050T00	±5	±300	50	None
IM05-0300C050T35	±5	±300	50	±35
IM05-0300C050T50	±5	±300	50	±50
IM05-0600C050T00	±5	±600	50	None
IM05-0600C050T35	±5	±600	50	±35
IM05-0600C050T50	±5	±600	50	±50
IM10-1200C050T00	±10	±1200	50	None
IM10-1200C050T35	±10	±1200	50	±35
IM10-1200C050T50	±10	±1200	50	±50

5.2 USB Data Acquisition (DAQ) Module Options

The USB DAQ is available to purchase with your IMU to facilitate simple data collection using a PC. The module converts the IMU RS422 output to USB signals and in the case of the USB-M-8.5UR model utilizes an internal charge pump to boost the USB 5 volt power up to 8.3 volts to power the IMU. Model numbers USB-M-8.5XR and USB-M-12-XR allow the use of an external power supply and have maximum voltages of 8.5 volts and 12 volts respectively. Each USB DAQ model number in Table 5 below is compatible with the Micro IMU and is available for order.

Table 5 - USB DAQ Module Options

Model Number	Description	Max Voltage	Power Source	Protocol
USB-M-8.5UR	µIMU USB RS422 DAQ, USB power	8.5V	USB	RS422
USB-M-8.5XR	µIMU USB RS422 DAQ, Ext. power	8.5V	External Power	RS422
USB-M-12XR	µIMU USB RS422 DAQ, 12V Ext. power	12V	External Power	RS422

5.3 Specifications

Table 6 – Specifications

PARAMETER	SPECIFICATION				UNITS	CONDITIONS
Operational Requirements						
Operating Supply Voltage	8.0 to 13.0				VDC	Unregulated; Note 1
Supply Current	180				mA	typical
Alignment Error	±1				%	
Mass	95				grams	
Acceleration	**IM02**	**IM05**	**IM10**			
Dynamic Range	± 2	± 5	± 10		g	
Offset	±30	± 30	± 30		mg	0 to 70 °C Maximum
Nonlinearity	± 0.4 (± 1.0)	± 0.4 (± 1.0)	± 0.4 (± 1.0)		% of FS	Typical (Maximum)
Noise	0.6 (0.8)	1.1 (1.3)	2.1 (2.8)		mg	Typical (Maximum), 1 σ
Digital Sensitivity	$9.1553x10^{-5}$	$2.2888x10^{-4}$	$4.5776\ x10^{-4}$		g/bit	See Equation 1 on page 8
Bandwidth [1]	50	50	50		Hz	-3dB point; Note 2
Angular Rate	**-0150C050**	**-0300C050**	**-0600C050**	**-1200C050**		
Dynamic Range	± 150	± 300	± 600	± 1200	°/s	
Offset	+/-1.5	+/-1.5	+/-1.5	+/-1.5	°/s	0 to 70 °C Maximum
Cross-Axis Sensitivity	+/-1	+/-1	+/-1	+/-1	%	Maximum
Nonlinearity	0.1	0.1	0.1	0.1	% of FS	Best fit straight line
Noise	0.36 (0.95)	0.56 (0.95)	0.56 (0.95)	0.56 (0.95)	°/s	Typical (Maximum), 1 σ
Digital Sensitivity	$6.8664x10^{-3}$	$1.3733x10^{-2}$	$2.7465x10^{-2}$	$5.4932x10^{-2}$	°/s/bit	See Equation 1 on page 8
Bandwidth [1]	50	50	50	50	Hz	-3dB point; Note 2
Magnetic Field						
Dynamic Range	±1.9				gauss	
Drift	2700				ppm/°C	
Nonlinearity	0.5				% of FS	Best fit straight line
Noise	0.00056 (0.0015)				gauss	Typical (Maximum), 1 σ
Digital Sensitivity	$8.6975x10^{-5}$				gauss/bit	See Equation 1 on page 8
Bandwidth[1]	50				Hz	-3dB point; Note 2
Optional Acceleration	**T35**	**T50**				
Dynamic Range	± 35	± 50			g	
Digital Sensitivity	$1.6022x10^{-3}$	$2.2888x10^{-3}$			g/bit	See Equation 1 on page 8
Noise	1.0	1.0			$mg/Hz^{½}$	
Bandwidth[1]	50	50			Hz	-3dB point; Note 2
Temperature						
Digital Sensitivity	$1.8165\ x\ 10^{-2}$				ºC/bit	
Absolute Max Ratings						
Acceleration Powered	2000 max				*g*	Any axis 0.5ms
Input Voltage Range	-0.3 (min) +13 (max)				VDC	Note 1
Operating Temperature	C - Commercial	M - Military			°C	
Temperature Range	0 to +70	-40 to +85				
Storage Temperature	-25 to +85				°C	

Typical Values at 25°C, V_{supply} = 8.3 VDC, 0 °/s, unless otherwise noted.
Note: µIMU T35 and T50 configurations are subject to U.S. Commerce Department export controls.

1. When using a USB Data Acquisition Board specified for a maximum voltage of 8.5 volts applying a higher voltage will damage the USB Data Acquisition Board. Optional 12 V version of USB DAQ is available.
2. Other bandwidth configurations are available upon request.

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6.0 Terms, Conditions and Warranty

DEFINITION *:* As used herein: "Seller" means MEMSense, 2693D Commerce Road, Rapid City, SD 57702. "Buyer" means the party purchasing Product(s) from the Seller. "Product" means all articles, materials, work or services offered by the Seller and described in the accompanying quotation, acknowledgement, invoice, or other Seller form. "Order" means any purchase Order or contract issued by the Buyer for Products provided by the Seller.

WARRANTY : Seller warrants that the Products will be free from defects in material and workmanship and conform in all material respects to their applicable specifications for a period of one (1) year from the date of delivery ("Warranty Period"), when operated under normal conditions and in accordance with their applicable specifications. For any breach of this warranty, Seller will, at its option and expense and as its sole obligation, and as Buyer's exclusive remedy, repair or replace any defective Product returned to Seller during the Warranty Period, provided that an examination by Seller discloses to Seller's reasonable satisfaction that a defect is covered by this warranty. This warranty does not apply to any Products that have been (i) subject to misuse, neglect, or abuse, (ii) improperly installed or maintained, or (iii) repaired or altered by anyone other than Seller. The warranty period for Products repaired or replaced under this warranty shall be limited to the components repaired or replaced and shall run for a period of one hundred and eighty (180) days from the date of delivery or the balance of the original one (1) year Warranty Period (excluding the time the Products were out of service and in Seller's plant), whichever is longer. EXCEPT AS STATED IN THIS SECTION, SELLER MAKES NO WARRANTIES, EXPRESS OR IMPLIED, AND SPECIFICALLY DISCLAIMS ANY IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE, MERCHANTABILITY, TITLE, AND NON-INFRINGEMENT OF THIRD PARTY RIGHTS.

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TAXES - Prices do not include sales or excise tax, VAT, duties or other governmental charges resulting from this transaction or the manufacture, sale, ownership, possession, or use of the Products, all of which must be paid by Buyer. Buyer shall provide Seller a tax exemption certificate acceptable to the taxing authorities.

SHIPMENT - Title to all purchased material and risk of loss therefore is passed from Seller to Buyer at the time of shipment from Seller's facility. Unless otherwise agreed upon in writing, all purchased material will be shipped uninsured. Seller may request partial shipment and invoice therefore.

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