MEMSENSE

Customer Focused Inertial Solutions

NANO IMU

Product Specification & User Guide

Document Number: DOC00290

Document Revision: J

MEMSENSE.COM

888.668.8743

Document Change History

REV	STATUS	DESCRIPTION	DATE
A	Obsolete	Initial Release	6-11-2008
B	Obsolete	Added section 5.2 USB DAQ Options and Table 5. Changed specifications table from 5 to 6. Removed the last page – Template Change tracking table.	9-29-2009
C	Obsolete	Changed title page photo. Changed Figure 1. Changed Table 6 "Supply Voltage" parameter name.	11-30-2009
D	Obsolete	Added pull up resistor recommendation to the I2C/SMBus section	11-15-2010
E	Obsolete	Updated USB DAQ section.	9-27-2011
F	Obsolete	Updated Logos and removed I2C options.	5-22-2013
G	Obsolete	Updated specifications and format.	6-4-2015
H	Obsolete	Updated velocity random walk parameters	1-28-2016
J	Released	Updated specifications for 2g accelerometer Digital Scale Factor.	6-9-2016

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1.0 OVERVIEW

The *NANO IMU* is a miniature, light weight IMU featuring outputs of acceleration, angular rate, and magnetic field. Digital outputs are factory configured to the RS422 protocol and custom algorithms provide real-time data corrected over the operating temperature range. The Nano IMU is provided in a composite thermoplastic housing measuring 1.835 in. x 0.903 in. x 0.56 in. and has a mass of a mere 20 grams.

2.0 SPECIFICATIONS

Table 1 - Specifications

ACCELERATION				*UNITS*	*NOTES*
Dynamic Range	**± 2**	**± 5**	**± 10**	g	Minimum
Bias Instability	33	75	163	μg	Typical
Offset	± 3.1	± 4.2	± 5.1	mg	Typical
Nonlinearity	± 0.4	± 0.4	± 0.4	% of FS	Typical
Velocity Random Walk	0.030	0.080	0.140	$m/s/h^{-1/2}$	Typical
Noise Density	81	166	363	$\mu g/Hz^{-1/2}$	Typical
Digital Scale Factor	9.1553E-05	2.2888E-04	4.5776E-04	g/bit	
Bandwidth [1]	50	50	50	Hz	-3dB point

ANGULAR RATE					*UNITS*	*NOTES*
Dynamic Range	**± 150**	**± 300**	**± 600**	**± 1200**	°/s	Minimum
Bias Instability	20	20	20	20	°/h	Typical
Offset	± 0.26	± 0.21	± 0.27	± 0.22	°/s	Typical
Nonlinearity	± 0.1	± 0.1	± 0.1	± 0.1	% of FS	Typical
Angle Random Walk	2.0	2.0	2.0	2.0	$°/h^{-1/2}$	Typical
Noise Density	0.051	0.051	0.055	0.065	$°/s/Hz^{-1/2}$	Typical
Digital Scale Factor	6.8665E-03	1.3733E-02	2.7465E-02	5.4932E-02	°/s /bit	
Bandwidth [1]	50	50	50	50	Hz	-3dB point

MAGNETIC FIELD		UNITS	NOTES
Dynamic Range	± 1.9	gauss	Minimum
Offset	± 0.005	gauss	Typical
Nonlinearity	± 0.5	% of FS	Typical
Noise Density	79.2	μgauss /$Hz^{-1/2}$	Typical
Digital Scale Factor	8.6975E-05	gauss /bit	
Bandwidth [1]	50	Hz	-3dB point

TEMPERATURE		UNITS	NOTES
Digital Scale Factor	1.8165E-02	°C/bit	

PHYSICAL		UNITS	NOTES
Dimensions	1.83 x 0.9 x 0.55	in.	(L x W x H)
Mass	20	grams	

OPERATIONAL REQUIREMENTS		UNITS	NOTES
Supply Voltage	5.4 to 9.0	VDC	
Supply Current	140	mA	
Interface Connector	Hirose HR30		6 pin

ABSOLUTE MAXIMUM RATINGS		UNITS	NOTES
Acceleration Powered	2000	*g*	0.5 ms any axis
Supply Voltage	-0.3 (min) to +12 (max)	VDC	
"C" Temperature Range	0 to 70	°C	
"M" Temperature Range	-40 to 85	°C	
Storage Temperature	-55 to 125	°C	

1) Other bandwidth configurations are available upon request.
2) Other configurations are available on a special order basis. Contact sales for more information.
3) Custom correction temperature profiles are available. Contact sales for more information.
4) Typical Values at 25°C, Supply Voltage = 7.0 VDC, 0 °/s, unless otherwise noted.

3.0 MECHANICAL

3.1 Dimensions

The Nano IMU is available in a custom package measuring 1.832 in. length × 0.546 in. height × 0.900 in. width. Holes are located in each corner allowing #0-80 machine screws to be utilized to mount the IMU to a PCB or chassis. Figure 1 depicts the physical dimensions of the part and its features.

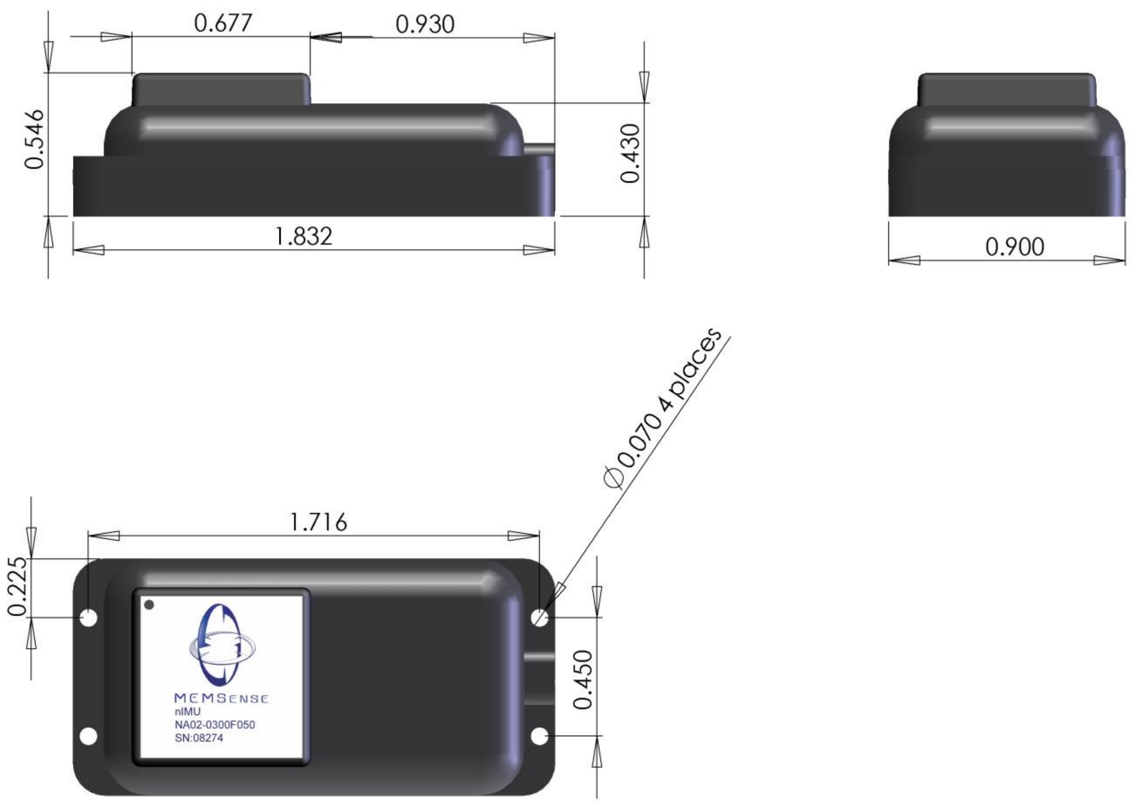

Figure 1 - Physical Dimensions

3.2 Coordinate System

The coordinate system for the IMU follows the right hand rule convention. The sign convention for the accelerometers is configured to produce a positive signal when the IMU is accelerated in the opposite direction of the axis arrow. As an example, the IMU pictured in Figure 2 below (given the X and Y axis are parallel to the earth's surface) will produce 0 *gs* for the X and Y axes and a positive 1 *g* for the Z-axis. As a further example, if the IMU were moved forward (left side of the page) the X-axis accelerometer would produce a positive output. A counterclockwise rotation of the IMU about any of the depicted axis will produce a positive angular rate output for the corresponding axis.

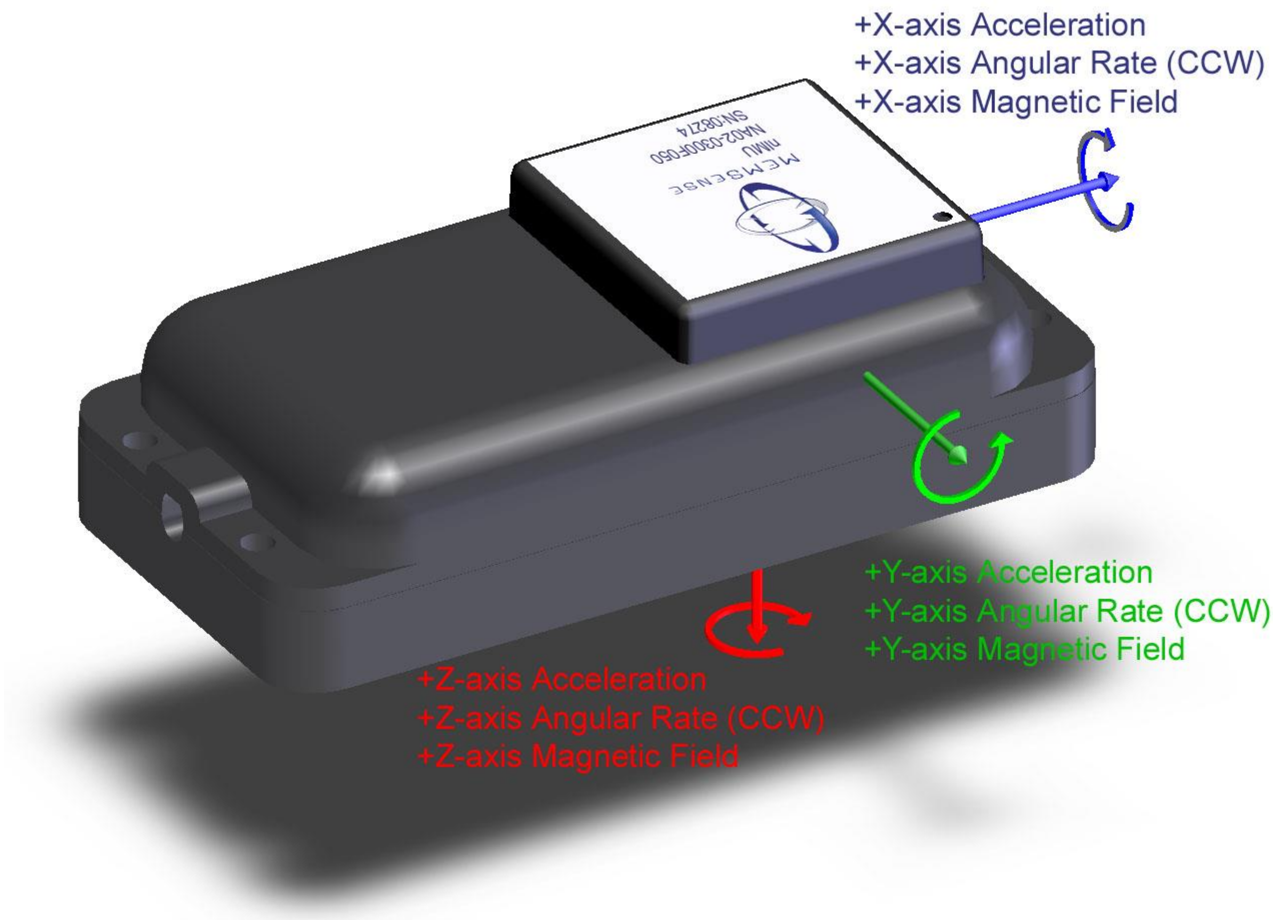

Figure 2 – Nano IMU coordinate system, side view

4.0 COMMUNICATIONS

4.1 Commands

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

4.2 Sample Format

Data samples are formatted as shown in Table 2. Each data channel (i.e. accelerometer, magnetometer, gyro) is represented by a signed (2's complement) 2-byte short (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 2 - Sample byte order/format

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

Message Header   Message Payload   Message Checksum

Graphically, the sample has the format shown in Figure 3:

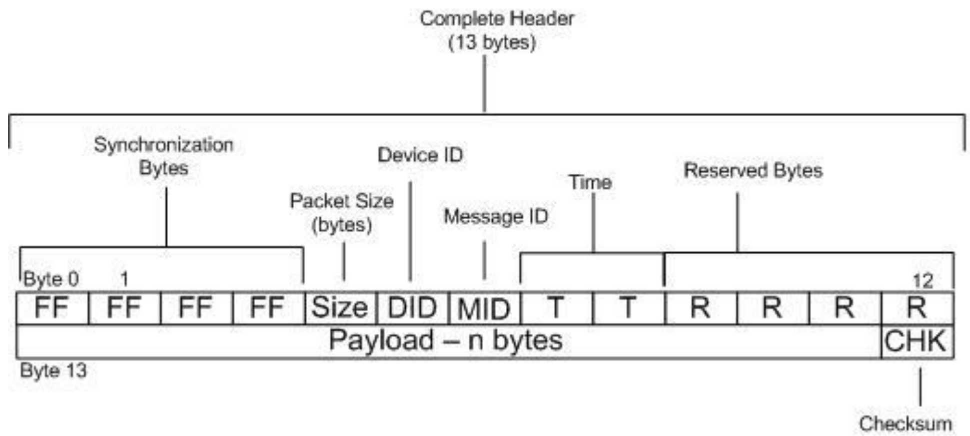

Figure 3 - Sample structure

The complete structure of a sample is detailed in Table 3.

Table 3 - Sample Element Descriptions

BYTE	ELEMENT	DESCRIPTION
0 - 3	Synchronization bytes	each byte encoded as 0xFF hex
4	Message size	Size in bytes of entire data packet including complete header
5	Reserved	
6	Message ID	Type of message. Data messages with MID = 0x14 hex (20 decimal).
7-8	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 x 10^{-6} seconds/count.
9-10	Reserved	
11-12	Serial Number	Unique number identifying each device
15	Payload	The payload size is calculated as follows: payload size = message size – 13(header) – 1(Checksum byte)
37	Checksum Byte	8-bit checksum byte. Sum sample contents (header + payload). DO NOT include the checksum byte. The summed value should equal the checksum if the message is valid. If larger than 8-bit addition is used to calculate the checksum, the checksum will be the remainder of a divide by 256.

4.3 Measurement

Accelerometer, gyro and magnetometer data is temperature compensated on the Nano IMU. 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_scale_factor*

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_scale_factor is the sensitivity expressed in engineering unit per bits. Digital scale factor values are listed in the Specification Table 1 (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 nIMU, the corresponding equations for the X component would be:

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

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

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.

Although the sensor data is temperature compensated, a customer's application may require the use of temperature information, therefore a temperature value obtained from each gyro 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 2:** result_deg_C = ($raw\_payload\_value\_x_{temperature}$ x *digital_scale_factor*) + 25]

where result is the converted value in degrees Celsius, raw_payload_value is the raw component-specific value from the payload in bits and the digital scale factor is the temperature sensitivity expressed in degrees C per bit (digital scale factors are listed in the Table 1 - Specifications).

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

Equation 3: *digital_scale_factor = dynamic_range* x 4.57764×10^{-5}

where digital scale factor 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).

5.0 HARDWARE

5.1 Connections

The Nano IMU ships with a 6 inch cable terminated with a Hirose HR-30 series miniature plastic in-line connector. In addition, it contains a built-in lock/release mechanism, is lightweight and corrosion resistant.

5.2 Pin Function Description

The pin functions for the IMU and mating connector are listed in Table 4 and 5 below:

Table 4 - Pin functions for HR30-6P-6S manufactured by HIROSE.

INTERFACE PIN FUNCTIONS – IMU Connector

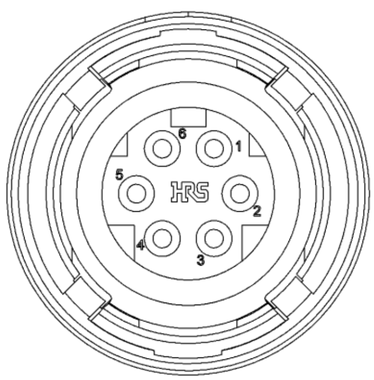

Figure 4 - HIROSE PN: HR30-6P-6S

Port No.	RS422/LVDS
1	Not Used
2	VDD
3	TX_Y
4	TX_Z
5	GND
6	Not Used

Table 5 - Mating Connector: Mates with Hirose HR30-6R-6P Male or HR30-6J-6P Inline Male)

INTERFACE PIN FUNCTIONS – Mating Connector

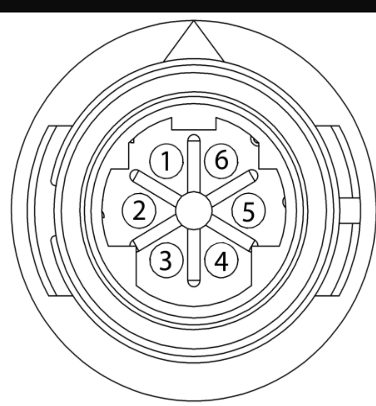

Figure 5 - *HR30-6J-6P*

Port No.	RS422/LVDS
1	Not Used
2	VDD
3	RX_A
4	RX_B
5	GND
6	Not Used

5.3 RS422 Connection Description

The Nano IMU RS422 and LVDS 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 IMU via the YZ differential driver pair and should be terminated with a 120 ohm resistor. The Nano IMU is not currently configured to receive data.

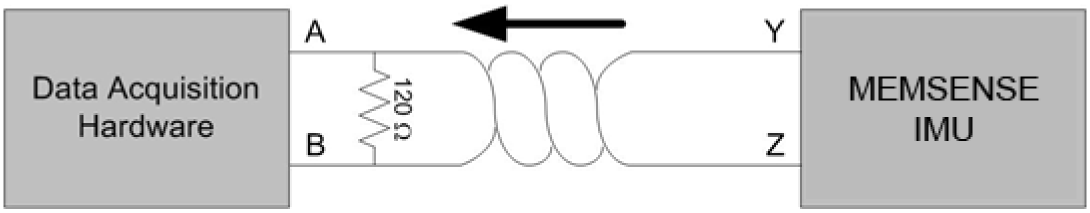

Figure 6– RS422 Full-duplex direct connection diagram

6.0 OPTIONS

6.1 Part Numbers

Table 6 - Standard Part Number

Part Number	Acceleration (g)	Angular Rate (°/s)	Magnetometer (gauss)	Bandwidth (Hz.)
NA05-0300F050R	±5	±300	±1.9	50

1.) Temperature Range of 0°C to 70°C add a “C” following the “R” in the Part Number
2.) Temperature Range of -40°C to 85°C add an “M” following the “R” in the Part Number
3.) Custom Bandwidth can be ordered contact sales for more information.

6.2 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-N-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 number USB-N-8.5XR allows the use of an external power supply and has a maximum voltage of 8.5 volts. Each USB DAQ model number in Table 7 below is compatible with the Nano IMU and is available for order.

Table 7 – USB DAQ Module Options

Part Number	Description	Max Voltage	Power Source	Protocol	Availability
USB-N-8.5UR	USB RS422 DAQ, USB power	8.5V	USB	RS422	Standard
USB-N-8.5XR	USB RS422 DAQ, Ext. power	8.5V	External Power	RS422	Option, specify on order