SX2 Series
Software Reference Manual

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Contents

Overview

This document is intended to be used as a basic software reference for interfacing with Gladiator Technologies inertial devices. This document provides details about the messaging protocol used, the byte sequences, and example code for interfacing with these devices. This reference provides the low-level details for developing device interfacing software.

This reference does not take the place of the Gladiator Measurement and Recording (Glamr) software package that accompanies Gladiator Technologies devices. Glamr is intended to serve as a "plug-and-play" application that provides an immediate user interface for inertial devices. Glamr can also be used to see the bytes being sent to and from Gladiator products with no software development required.

1 Safety and Handling Information

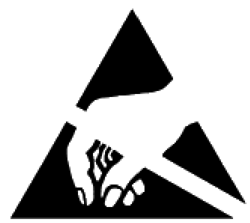
CAUTION: SUPPLYING THE UNIT WITH A HIGH INPUT VOLTAGE COULD CAUSE PERMANENT DAMAGE.

Supply voltage is specified in the datasheet for your device. Confirm proper input voltage settings before use.

Gladiator devices are sensitive scientific instruments containing shock and vibration sensitive inertial sensors. Excessive shock and/or vibration can damage these sensors and can adversely affect sensor performance and unit output.

Avoid exposure to electrostatic discharge (ESD). Observe proper grounding whenever handling the device.

Properly attach connector and ensure that it has been wired correctly before applying power to the device.



2 VELOX® & VELOX® Plus

Gladiator SX2 products are enabled with VELOX® high speed processing, a Gladiator Technologies proprietary technology for rapid sampling. VELOX® technology is the driver for increased data outputs, increased filtering options and extremely low latency.

VELOX® is also available with enhanced options in the VELOX® Plus package. These upgraded features include higher bandwidth, message rates, and Baud rates from the standard product offering. In addition, custom data rates are available.

The Glamr interface software will display the VELOX® or VELOX® Plus status of each connected device. This status is also available in the device status message. See section 8 for more details.

3 Communication Layers

3.1 Physical Interface

Gladiator devices communicate via a differential serial interface that is either:
RS-422
RS-485

Gladiator devices do not support multiple devices on the same bus. Serial communication is half-duplex and only supports communication in one direction (to the host, or to the device, not both simultaneously).

The supported serial baud rates include:

- 115.2 Kbps
- 921.6 Kbps
- 1.5 Mbps
- 3.0 Mbps
- 6.0 Mbps[1]
- 7.5 Mbps[1]
- Other[1]

One byte is defined as having 1 start bit, 8 data bits, even parity, and 1 stop bit (8E1). Thus, there are 11 bits of data transmitted/received per byte.

[1] Only available with VELOX® Plus enabled devices.

3.2 Data Link Interface

The data link interface defines the messages of data sent to/from the Gladiator device. A message is defined to be a series of bytes that include a known sync byte and some number of predefined bytes based on the sync byte.

Description	Number of Bytes	Value
Sync Byte	1	Context specific
Message Contents	0 to 1023	Based on sync byte
Total Size	1 to 1024	

3.2.1 Messages from the Device

Gladiator devices are configured such that at power up, the device will continuously output messages to the host based on the last configured mode. The mode defines the "Sync Byte" and the number of bytes in the message. For the device, the following modes are defined:

Mode	Sync Byte	Number of Bytes
IMU16	0x2A	18
IMU24	0x37	24
IMU32	0x33	30
TRIAX16	0x2F	12
TRIAX24	0x39	15
TRIAX32	0x36	18
BIAX16	0x2E	10
BIAX24	0x38	12
BIAX32	0x35	14
COEF[2]	0x4D	266
COEFNUM[2]	0x4E	36

For all modes, the message format looks as follows:

Description	Number of Bytes	Value
Sync Byte	1	Context specific
Message Contents	0 to 1023	Based on sync byte
Checksum	1	Two's complement sum of bytes including the sync byte
Total Size	2 to 1024	

Refer to section 4 for the details of each message mode and how to interpret bytes. Refer to section 11 to see how you can view these message bytes with Glamr.

[2]These modes do not persist across power up and are used to send coefficients and calibration data to the host. These modes are not typically utilized outside of the factory.

3.2.2 Messages to the Device

The Gladiator device is listening on the communications port for messages from the host to configure the device. As this port is a half-duplex bus, the device and the host can NOT transmit at the same time. Bi-directional communications require a handshake between host and device. This is accomplished by the "UNLOCK" byte.

The "UNLOCK" byte is 0xD4. When the device sees this byte, it will stop sending mode messages to the host for 2000 ms. This gives the host time to send messages to the device without being interrupted.

The format of the messages to the device are as follows:

Description	**Number of Bytes**	**Value**
Sync Byte	1	0x2B
Command	1	Command
Parameter	1	Command parameter
Checksum	1	Two's complement sum of bytes including the sync byte
Data Value	4	Command data value

Refer to section 7 for details of each message. Refer to section 11 to see how you can view these message bytes with Glamr.

3.2.3 Host Lock

Products may have a "host lock" option enabled. In this case, messages from the host will only be received within the first 15 seconds after power-up. This includes the "UNLOCK" command. These devices must receive a valid command within the first 15 seconds of powering up to receive further messages from the host.

If a valid command is received within this window the device will keep host communications open until power is lost or the device is commanded to reset.

4 Messages from Device Protocol - Detailed

The messages from the device to the host are described in this section in detail.

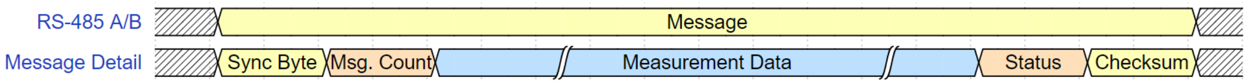


Figure 1: Generic message structure from Gladiator Technologies' devices.

All signed values are expressed in two's complement format. Multi-byte values are sent in little-endian format (LSB first).

4.1 BIAX16 Message Protocol

Byte Count	Message Parameter	Byte Order	Data Type	Scale Factor / Value
1	Sync	LSB[7:0]	N/A	0x2E (46)
2	Message counter	LSB[7:0]	N/A	0x00 to 0xFF (0 to 255)
3 4	Gyro-X	LSB[7:0] MSB[15:8]	Signed	Varies (Deg/s)[3]
5 6	Gyro-Y	LSB[7:0] MSB[15:8]	Signed	Varies (Deg/s)[3]
7 8	Temperature	LSB[7:0] MSB[15:8]	Signed	0.01°C
9	Status Indicator	LSB[7:0]	N/A	See section 8
10	Checksum	LSB[7:0]	N/A	Two's complement sum of all previous bytes

[3] The gyro LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

4.2 BIAX24 Message Protocol

Byte Count	Message Parameter	Byte Order	Data Type	Scale Factor / Value
1	Sync	LSB[7:0]	N/A	0x38 (56)
2	Message counter	LSB[7:0]	N/A	0x00 to 0xFF (0 to 255)
3 4 5	Gyro-X	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (Deg/s)[4]
6 7 8	Gyro-Y	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (Deg/s)[4]
9 10	Temperature	LSB[7:0] MSB[15:8]	Signed	0.01°C
11	Status Indicator	LSB[7:0]	N/A	See section 8
12	Checksum	LSB[7:0]	N/A	Two's complement sum of all previous bytes

[4]The gyro LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

4.3 BIAX32 Message Protocol

Byte Count	Message Parameter	Byte Order	Data Type	Scale Factor / Value
1	Sync	LSB[7:0]	N/A	0x35 (53)
2	Message counter	LSB[7:0]	N/A	0x00 to 0xFF (0 to 255)
3 4 5 6	Gyro-X	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (Deg/s)[5]
7 8 9 10	Gyro-Y	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (Deg/s)[5]
11 12	Temperature	LSB[7:0] MSB[15:8]	Signed	0.01°C
13	Status Indicator	LSB[7:0]	N/A	See section 8
14	Checksum	LSB[7:0]	N/A	Two's complement sum of all previous bytes

[5]The gyro LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

4.4 TRIAX16 Message Protocol

Byte Count	Message Parameter	Byte Order	Data Type	Scale Factor / Value
1	Sync	LSB[7:0]	N/A	0x2F (47)
2	Message counter	LSB[7:0]	N/A	0x00 to 0xFF (0 to 255)
3 4	Gyro-X	LSB[7:0] MSB[15:8]	Signed	Varies (Deg/s)[6]
5 6	Gyro-Y	LSB[7:0] MSB[15:8]	Signed	Varies (Deg/s)[6]
7 8	Gyro-Z	LSB[7:0] MSB[15:8]	Signed	Varies (Deg/s)[6]
9 10	Temperature	LSB[7:0] MSB[15:8]	Signed	0.01°C
11	Status Indicator	LSB[7:0]	N/A	See section 8
12	Checksum	LSB[7:0]	N/A	Two's complement sum of all previous bytes

[6]The gyro LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

4.5 TRIAX24 Message Protocol

Byte Count	Message Parameter	Byte Order	Data Type	Scale Factor / Value
1	Sync	LSB[7:0]	N/A	0x39 (57)
2	Message counter	LSB[7:0]	N/A	0x00 to 0xFF (0 to 255)
3 4 5	Gyro-X	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (Deg/s)[7]
6 7 8	Gyro-Y	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (Deg/s)[7]
9 10 11	Gyro-Z	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (Deg/s)[7]
12 13	Temperature	LSB[7:0] MSB[15:8]	Signed	0.01°C
14	Status Indicator	LSB[7:0]	N/A	See section 8
15	Checksum	LSB[7:0]	N/A	Two's complement sum of all previous bytes

[7]The gyro LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

4.6 TRIAX32 Message Protocol

Byte Count	Message Parameter	Byte Order	Data Type	Scale Factor / Value
1	Sync	LSB[7:0]	N/A	0x36 (54)
2	Message counter	LSB[7:0]	N/A	0x00 to 0xFF (0 to 255)
3 4 5 6	Gyro-X	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (Deg/s)[8]
7 8 9 10	Gyro-Y	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (Deg/s)[8]
11 12 13 14	Gyro-Z	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (Deg/s)[8]
15 16	Temperature	LSB[7:0] MSB[15:8]	Signed	0.01°C
17	Status Indicator	LSB[7:0]	N/A	See section 8
18	Checksum	LSB[7:0]	N/A	Two's complement sum of all previous bytes

[8] The gyro LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

4.7 IMU16 Message Protocol

Byte Count	Message Parameter	Byte Order	Data Type	Scale Factor / Value
1	Sync	LSB[7:0]	N/A	0x2F (47)
2	Message counter	LSB[7:0]	N/A	0x00 to 0xFF (0 to 255)
3 4	Gyro-X	LSB[7:0] MSB[15:8]	Signed	Varies (Deg/s)[9]
5 6	Gyro-Y	LSB[7:0] MSB[15:8]	Signed	Varies (Deg/s)[9]
7 8	Gyro-Z	LSB[7:0] MSB[15:8]	Signed	Varies (Deg/s)[9]
9 10	Accel-X	LSB[7:0] MSB[15:8]	Signed	Varies (mg)[10]
11 12	Accel-Y	LSB[7:0] MSB[15:8]	Signed	Varies (mg)[10]
13 14	Accel-Z	LSB[7:0] MSB[15:8]	Signed	Varies (mg)[10]
15 16	Temperature	LSB[7:0] MSB[15:8]	Signed	0.01°C
17	Status Indicator	LSB[7:0]	N/A	See section 8
18	Checksum	LSB[7:0]	N/A	Two's complement sum of all previous bytes

[9] The gyro LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

[10] The accel LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

4.8 IMU24 Message Protocol

Byte Count	Message Parameter	Byte Order	Data Type	Scale Factor / Value
1	Sync	LSB[7:0]	N/A	0x39 (57)
2	Message counter	LSB[7:0]	N/A	0x00 to 0xFF (0 to 255)
3 4 5	Gyro-X	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (Deg/s)[11]
6 7 8	Gyro-Y	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (Deg/s)[11]
9 10 11	Gyro-Z	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (Deg/s)[11]
12 13 14	Accel-X	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (mg)[12]
15 16 17	Accel-Y	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (mg)[12]
18 19 20	Accel-Z	LSB[7:0] [15:8] MSB[23:16]	Signed	Varies (mg)[12]
21 22	Temperature	LSB[7:0] MSB[15:8]	Signed	0.01°C
23	Status Indicator	LSB[7:0]	N/A	See section 8
24	Checksum	LSB[7:0]	N/A	Two's complement sum of all previous bytes

[11] The gyro LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

[12] The accel LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

4.9 IMU32 Message Protocol

Byte Count	Message Parameter	Byte Order	Data Type	Scale Factor / Value
1	Sync	LSB[7:0]	N/A	0x36 (54)
2	Message counter	LSB[7:0]	N/A	0x00 to 0xFF (0 to 255)
3 4 5 6	Gyro-X	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (Deg/s)[13]
7 8 9 10	Gyro-Y	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (Deg/s)[13]
11 12 13 14	Gyro-Z	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (Deg/s)[13]
15 16 17 18	Accel-X	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (mg)[14]
19 20 21 22	Accel-Y	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (mg)[14]
23 24 25 26	Accel-Z	LSB[7:0] [15:8] [23:16] MSB[31:24]	Signed	Varies (mg)[14]
27 28	Temperature	LSB[7:0] MSB[15:8]	Signed	0.01°C
29	Status Indicator	LSB[7:0]	N/A	See section 8
30	Checksum	LSB[7:0]	N/A	Two's complement sum of all previous bytes

[13]The gyro LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

[14]The accel LSB weighting is based on the Gladiator Model and series number of the device. This can be decoded from the "Status Indicator" described in subsequent sections.

4.10 COEF Message Protocol

Description	**Number of bytes**	**Value**
Sync Byte	1	0x4D
Message counter	1	Mod 256 counter
Coefficient page no.	1	Unsigned char
Coefficient page index	1	Unsigned char
Coefficient value	4	Signed 32-bit float
Format string	Up to 127	ASCII characters
Semicolon separator	1	0x3B (';')
Semicolon separator	1	0x3B (';')
Semicolon separator	1	0x3B (';')
Semicolon separator	1	0x3B (';')
Null padding	Varies	0x00 (NUL)
Status indicator	1	See section 8
Checksum	1	0x00
Total Size	**266**	

4.11 COEFNUM Message Protocol

Description	**Number of bytes**	**Value**
Sync Byte	1	0x4E
Message counter	1	Mod 256 counter
Coefficient page number & entries per page	32	16 Two-byte pairs: [Coefficient page #, Number of page entries]
Status indicator	1	See section 8
Checksum	1	0x00
Total Size	**266**	

4.12 Total Message Transport Time

Total transport time defines the maximum message rate that can used with the device. Total time can be computed by:

$$time = \frac{(bytes * bits/byte)}{baud} \tag{1}$$

For example, in IMU16 mode at 1.5 Mbaud:

$$\frac{(18bytes * 11bits/byte)}{1.5Mbps} = 0.132ms \tag{2}$$

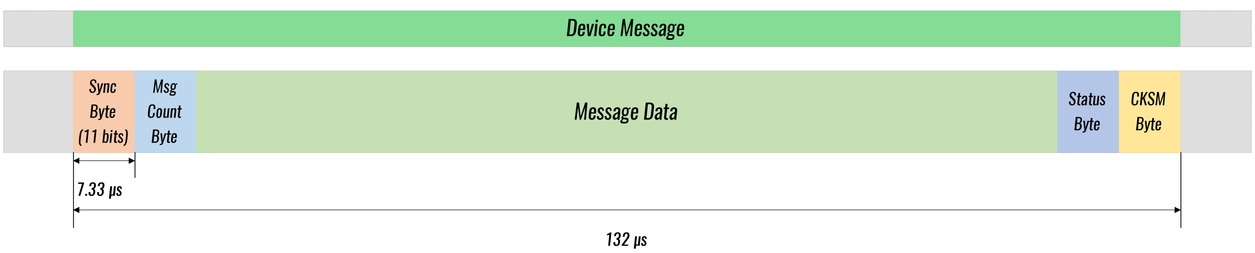


Figure 2: Transport time for 18 bytes at 1.5 Mbaud.

5 Message Field Descriptions

5.1 Sync Byte

The "Sync Byte" is a byte that uniquely defines the format (context and number) of the message bytes to follow.

5.2 Message Count

The "Message Count" is an incremental number from 0 to 255, which then resets back to 0. This can be used to determine if messages are getting dropped, as well as provide context for the status byte value (see below).

5.3 Gyro

The "Gyro" fields are 16/24/32-bit signed values (2's complement in little-endian format, LSB first). The value multiplied by the gyro scaling provides the actual gyro value in degrees per second.

5.4 Accel

The "Accel" fields are 16/24/32-bit signed values (2's complement in little-endian format, LSB first). The value multiplied by the accel scaling provides the actual accel value in milli-g's.

5.5 Temperature

The "Temperature" field is 16-bit signed value (in little-endian format, LSB first). The value multiplied by 0.01 provides the temperature in the device in Degrees Celsius.

5.6 Status Indicator

The "Status Indicator" field definition varies with the "Message Count" to provide information about the device that is not changing as fast as the message rate. These attributes include:

- Gyro Scaling Information
- Accel Scaling Information
- External Sync Input Status
- Self-Test Input Status
- Internal Error Status
- Bandwidth Filter Settings
- Device Firmware Version

Refer to section 8 for details on how to decode the "Status Indicator" byte based on "Message Count."

5.7 Checksum

The Checksum is computed by taking the two's complement of the sum of the other bytes within the message. Thus, performing a byte-wide sum of all bytes in the message (including the Checksum byte) always equates to zero.

5.8 Extended Status

Devices can provide additional device status information. This extended status overrides the default "Status Indicator" field. The extended status information can be enabled/disabled via settings in the device coefficients. Refer to section 9 for details on how to decode the "Extended Status Indicator."

Note: When the extended status option is enabled, all synchronization bytes ("Sync Bytes") will have their MSB set. For example, in IMU16 mode with extended status **disabled** the sync byte would be: 0x2A. In IMU16 mode with extended status **enabled** the sync byte would be: 0xAA. This could pose an issue for backwards compatibility in existing systems which is why the option to disable the extended status exists.

6 External Sync

The device operates on an internal clock (which is internally divided for output) until an external clock is detected. The rising edge of External Sync is used to latch the sensors and the falling edge is used to trigger the serial message output. The External Sync signal is ignored until after the device is initialized. Then the device will automatically switch over and set Status Bit 1 (true). To align, the period between rising edges must be within 0.5% of each other as measured by a 1.5 MHz clock and four rising edges, or after 30 consecutive rising edges.

The status bit will be set true during the transition period, as well. When the Message Counter is reset to zero, this will be the first data package with all samples on the external clock.

Refer to the timing diagram of your specific device to see the relationship between the external clock and data transmission (found on the Gladiator website product page). The device will revert to the internal clock if the external clock is not present for 10 ms (<100 Hz external clock), disable External Sync, and restart the rising edge counter. There is a 258 ns edge-detect filter enabled on this signal to avoid triggering on glitches.

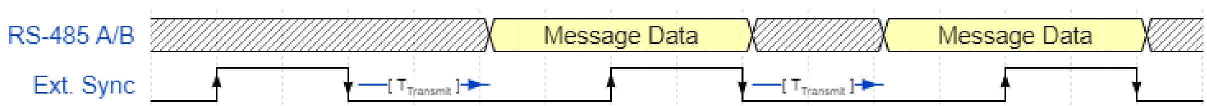


Figure 3: External Sync waveform example showing how serial data is synchronized.

7 Messages to Device Protocol - Detailed

The messages from the host to the device are described in detail in this section. Before the host sends messages to the device, it is recommended that host send multiple "UNLOCK" bytes to the device. This will pause the device for 2000 ms to allow the host time to send a message. If the host continues to send messages, then the "UNLOCK" message does not need to be sent between messages.

7.1 UNLOCK Byte

The "UNLOCK" byte is 0xD4. When the device sees this byte, it will stop sending mode messages to the host for 2000 ms.

7.2 Messaging Modes

The following commands set/change the device output message characteristics. Please recognize that it is possible to set the message rate higher than the baud rate may support. In this case, the device will output messages as fast as it can, but it will not meet the commanded message rate. This should be avoided as it will saturate the half-duplex

Description	**Command**	**Parameter**	**Data Value**
Message Rate	0x31	0x00	Float32 (ODR [Hz])[15]
Baud Rate	0x2F	0x00	Float32 (9600 - 7.5M)[16]
Data Format	0x34	0x00	Float32 (16, 24, 32)

Using the message format as described in section 7, here is an example of setting the message rate to 100 Hz:

Description	**Number of bytes**	**Value**
Sync Byte	1	0x2B
Command	1	0x31
Parameter	1	0x00
Checksum	1	0x9A
Data Value	4	0x41C80000 (100.0 Hz)

Checksum: 0X2B + 0X31 + 0X00 + 0X9A + 0X42 + 0XC8 + 0X00 + 0X00 = 0X00 (MOD 256)

[15] Supported message rates range from 10 Hz to 5kHz, and 10 kHz with VELOX® Plus.

[16] The maximum baud rate is 3.0 Mbaud, and 7.5 Mbaud with VELOX® Plus.

7.3 Coefficient Messages

The Coefficient messages allow the host to set each coefficient to a specific value, save these to persistent storage (so they are recalled at next power cycle), and restore factory defaults.

7.3.1 Load Coefficient

To save a specific value at a specific location in the coefficient pages, the message format looks as follows:

Description	**Number of bytes**	**Value**
Sync Byte	1	0xB2
Coefficient Page No.	1	0 - 15
Coefficient Page Index No.	1	0 - 255
Checksum	1	Forcing Checksum
Data Value	4	Value to save

Refer to section 10 for details on device coefficients and their values.

7.3.2 Store Coefficients

Once all the coefficients have been loaded, the host can send a message to have the device save these values to persistent storage. This will allow changes to be preserved across power cycles. The format of this message is as follows:

Description	**Number of bytes**	**Value**
Sync Byte	1	0xB2
Command	1	0x04
Parameter	1	Number of coefficient values set
Checksum	1	Forcing Checksum
Data Value	4	0x00

7.3.3 Restore Factory Coefficients

The factory default coefficients cannot be changed. However, they can be recalled to restore the system to the original factory settings. This message has the following format:

Description	**Number of bytes**	**Value**
Sync Byte	1	0x2B
Command	1	0x1D
Parameter	1	0x00
Checksum	1	0xB8
Data Value	4	0x00

8 Appendix A – Status Indicator Decoding

All messages coming from the device have a "Message Count" byte and a "Status Indicator" byte. Together, these two bytes provide various information about the device that may be of importance.

Message Count	Bit 7	Name	Value (Bits 6:0)
0	0	Firmware Major Revision Number	0 - 127
0	1	Firmware Product Code	0 - 127
1	0	Firmware Minor Revision Number	0 - 127
1	1	Firmware Release Level Number	0 - 127
247	X	Band pass filter frequency (Hz)	Bandwidth/4
248 - 251	X	Product Name String	0 - 255 (ASCII Characters)
252 - 255	X	Serial Number String	0 - 255 (ASCII Characters)

Note: The Product Name String is a ASCII character string (up to 128 characters) where the first character in the string is flagged by a set upper bit in the status byte.

Example: "G300D" would be received in the following way:

Message Count	Status Byte	Character
248	0xC7	'G'
249	0x33	'3'
250	0x30	'0'
251	0x30	'0'
248	0x44	'D'
249	0x00	'NULL'

Note: The Serial Number String is a ASCII character string (up to 128 characters) where the first character in the string is flagged by a set upper bit in the status byte.

Example: "1234" would be received in the following way:

Message Count	Status Byte	Character
252	0xB1	'1'
253	0x32	'2'
254	0x33	'3'
255	0x34	'4'
252	0x00	'NULL'

8.1 Status Byte Decoding when Bit 6 is Zero

Bit	Name	Value
0	VELOX® Plus indicator	1=Device VELOX® Plus enabled
1	Sync	1=External Sync, 0=Internal Sync
2	Interface error	1=Internal Interface Failure
3	Flash checksum error	1=Flash Coefficient Checksum failure
4	Software error	1=Internal Software Failure
5	Software timing error	1=Software Missed Real-time
6	Status byte select	0 (bits 2-5, bit 7 are status)
7	Self-test	1=Self-test Active

8.2 Status Byte Decoding when Bit 6 is One

Bit	Name	Value
0	Gyro Range bit 0	See gyro decode table below
1	Accel Range bit 0	See accel decode table below
2	Accel Range bit 1	See accel decode table below
3	Accel range bit 2	See accel decode table below
4	Gyro Range bit 1	See gyro decode table below
5	Gyro Range bit 2	See gyro decode table below
6	Status byte select	1 (bits 2-5, bit 7 are settings)
7	RESERVED	RESERVED

8.3 Gyro Decoding Table

Model	Name	Value
G300D LMRK005 LMRK007 LMRK007X	Gyro Decode Range	000b=RESERVED 001b=100 °/s 010b=RESERVED 011b=490 °/s 100b=RESERVED 101b=2000 °/s 110b=250 °/s 111b=1000 °/s

The least significant bit (LSB) of a gyro value can be derived from the gyro range and the format of the message being either 16, 24, or 32 bits. The basic formula is to take the gyro range and divide it by the number of LSB's in the data resolution format.

Range (°/s)	16-Bit (°/s)	24-Bit (°/s)	32-Bit (°/s)
100[17]	0.0031	0.00001192	0.0000000466
250[17]	0.0076	0.00002980	0.0000001164
490	0.0150	0.00005841	0.0000002282
1000[17]	0.0305	0.00011921	0.0000004657
2000	0.0610	0.00023842	0.0000009313

[17] Not all gyro ranges are standard. Please contact Gladiator Technologies support for custom range options.

8.4 Accel Decoding Table

Model	Name	Value
LMRK005	Accel Decode Range	000b=15 g 001b=RESERVED 010b=2 g 011b=6 g 100b=10 g 101b=16 g 110b=RESERVED 111b=RESERVED
A300D LMRK007 LMRK007X	Accel Decode Range	000b=15 g 001b=98 g 010b=131 g 011b=RESERVED 100b=RESERVED 101b=RESERVED 110b=40 g

The least significant bit (LSB) of an Accel value can be derived from the Accel range and the format of the message being either 16, 24, or 32 bits. The basic formula is to take the Accel range and divide by the number of LSB's in the data resolution format.

Range (g)	16-Bit (mg)	24-Bit (mg)	32-Bit (mg)
2 - 3[18]	0.100	0.000391	0.000001526
4 - 16	0.500	0.001953	0.000007629
32[18]	1.000	0.003906	0.000015259
40[18]	1.200	0.004688	0.000018311
65[18]	2.000	0.007813	0.000030518
98[18]	3.000	0.011682	0.000045634
131[18]	4.000	0.015625	0.000061035
200[18]	6.000	0.023841	0.000093132

[18] Not all accel ranges are standard. Please contact Gladiator Technologies support for custom range options.

9 Appendix B – Extended Status Decoding

The extended status information is defined by the "Status Indicator" byte and the "Message Count" (sequence number) byte. This is an optional feature that can be disabled if necessary. Some of the status decoding rules are the same as those found in section 8. The decoding rules are the same for the following message count values:

- 0 - 3
- Values evenly divisible by 20 (20, 40, 60...)
- 247 - 255

The tables below describe the new decoding rules:
If message count = 0 - 3:

Message Count	Bit 7	Name	Value (Bits 6:0)
0	0	SW Major Revision No.	0 to 127
0	1	SW Product Code	0 to 127
1	0	SW Minor Revision No.	0 to 127
1	1	SW Release Revision No.	0 to 127
2	0	RESERVED	RESERVED
2	1	RESERVED	RESERVED
3	0	RESERVED	RESERVED
3	1	RESERVED	RESERVED

If message count = 20, 40, 60, 80, 120, 140, 160, 180, 200, 220, 240:

Bit 6	Bits (7:0)	Name	Value
0	0	VELOX® Indicator	1=Device VELOX® Plus Enabled
0	1	Sync	1=External Sync, 0=Internal Sync
0	2	Interface Error	1=Internal Interface Failure
0	3	Flash Checksum Error	1=Flash Coefficient Checksum Failure
0	4	Software Error	1=Internal Software Failure
0	5	Software Timing Error	1=Software Missed Real-Time
0	**6**	**Status Byte Select**	**0 (bits 2-5, bit 7 are status)**
0	7	Self-Test	1=Self-Test Active
1	0	Gyro Range bit 0	See gyro decode table below
1	1	Accel Range bit 0	See accel decode table below
1	2	Accel Range bit 1	See accel decode table below
1	3	Accel range bit 2	See accel decode table below
1	4	Gyro Range bit 1	See gyro decode table below
1	5	Gyro Range bit 2	See gyro decode table below
1	**6**	**Status Byte Select**	**1 (bits 2-5, bit 7 are status)**
1	7	RESERVED	RESERVED

If message count = 4 - 19 (These are ASCII values):

Message Count	Configuration Status Byte
4	Boot Code CRC
5	Application Code CRC
6	Coefficient User CRC
7	Coefficient Factory CRC
8 - 19	RESERVED

If message count = 21 - 39:

Message Count	Error Status Byte
21	**Reset Cause** 0x01 – Power 0x02 – Power Low 0x04 – Loss of PLL Clock 0x08 – Reset Pin (JTAG) 0x10 – Software Reset 0x20 – Core Lockup
22	**Power Detect** Supply Voltage = value / 10.0
23	**Power Up Test** 0x00 – Nominal 0x01 – Configuration Failure 0x02 – Sensor Stage 1 Read Failure 0x04 – Sensor State 2 Read Failure 0x08 – Built-in Test has run at least once (refer to status bytes 41-59 for details of pass/fail results) 0x10 – Sensor Stage 1 Read Failure 0x20 – Sensor State 2 Read Failure
24	**Flash Lock** 0x01 – AHRS 0x02 – Kalman 0x04 – Coefficients Locked 0x08 – Host Serial Locked 0x10 – External Sync Locked

25	**Configuration Error Mask** 0x01 – AHRS User Configuration Invalid 0x02 – AHRS Factory Configuration Invalid 0x04 – Cal User Configuration Invalid 0x08 – Cal Factory Configuration Invalid
26	**Sensor Error Mask** 0x01 – Gyro Failure 0x02 – Accel Failure 0x04 – Temp Failure 0x08 – Mag Failure 0x10 – Pressure Failure
27	**External Sync** 0x01 – External Sync Present 0x02 – External Sync Present (but disabled) 0x04 – Too Fast For Processor 0x08 – Too Fast For Baud Rate
28	**Self-Test** 0x01 – Self-Test Present and Running
29	**Messaging** 0x00 – Normal Messaging 0x01 – Message Rate Too Fast For Sensor Fusion 0x02 – Message Rate Too Fast For Baud Rate 0x04 – Software Error During Message Processing 0x08 – Source Voltage Out of Specification Range
30	**Bandwidth** Gyro and Accel Bandwidth = Value / 4.0
31	RESERVED
32	RESERVED
33 - 34	Unit configuration ASCII character string (up to 128 characters) where the first character is flagged by a set upper bit in the status byte.
35 - 39	RESERVED

If message count = 41 - 59:

Message Count	Status Byte
41	**XGYR Built-In Test Failure Cause** 0x01 – Movement Detected Stage 1 0x02 – Signal Low In Stage 1 0x04 – Signal High In Stage 1 0x10 – Movement Detected Stage 2 0x20 – Signal Low In Stage 2 0x40 – Signal High In Stage 2
42	**YGYR Built-In Test Failure Cause** 0x01 – Movement Detected Stage 1 0x02 – Signal Low In Stage 1 0x04 – Signal High In Stage 1 0x10 – Movement Detected Stage 2 0x20 – Signal Low In Stage 2 0x40 – Signal High In Stage 2
43	**ZGYR Built-In Test Failure Cause** 0x01 – Movement Detected Stage 1 0x02 – Signal Low In Stage 1 0x04 – Signal High In Stage 1 0x10 – Movement Detected Stage 2 0x20 – Signal Low In Stage 2 0x40 – Signal High In Stage 2
44	**XACC Built-In Test Failure Cause** 0x01 – Movement Detected Stage 1 0x02 – Signal Low In Stage 1 0x04 – Signal High In Stage 1 0x10 – Movement Detected Stage 2 0x20 – Signal Low In Stage 2 0x40 – Signal High In Stage 2

45	**YACC Built-In Test Failure Cause** 0x01 – Movement Detected Stage 1 0x02 – Signal Low In Stage 1 0x04 – Signal High In Stage 1 0x10 – Movement Detected Stage 2 0x20 – Signal Low In Stage 2 0x40 – Signal High In Stage 2
46	**ZACC Built-In Test Failure Cause** 0x01 – Movement Detected Stage 1 0x02 – Signal Low In Stage 1 0x04 – Signal High In Stage 1 0x10 – Movement Detected Stage 2 0x20 – Signal Low In Stage 2 0x40 – Signal High In Stage 2
47	**GYRO Runtime Test Failure Cause** 0x01 – Acquisition Time Failure 0x02 – XGYR failure 0x04 – YGYR failure 0x08 – ZGYR failure
48	**ACCEL Runtime Test Failure Cause** 0x01 – Acquisition Time Failure 0x02 – XACC failure 0x04 – YACC failure 0x08 – ZACC failure
49 - 59	RESERVED

All other values are reserved.

10 Appendix C – Coefficient Parameters

Coefficient parameter definitions:

Coefficient Page	Index	Name	Data Type	Value	Units
0 (Standard Configuration)	1	Gyro Bandwidth[19]	Float32	150 - 600	Hz
	2	Accel Bandwidth[19]	Float32	150 - 600	Hz
1 (Advanced Configuration)	1	Extended Mode	Unsigned32	Varies	-
	2	Unit to body (0,0)	Float32	1.0 (Default)	-
	3	Unit to body (0,1)	Float32	0.0 (Default)	-
	4	Unit to body (0,2)	Float32	0.0 (Default)	-
	5	Unit to body (1,0)	Float32	0.0 (Default)	-
	6	Unit to body (1,1)	Float32	1.0 (Default)	-
	7	Unit to body (1,2)	Float32	0.0 (Default)	-
	8	Unit to body (2,0)	Float32	0.0 (Default)	-
	9	Unit to body (2,1)	Float32	0.0 (Default)	-
	10	Unit to body (2,2)	Float32	1.0 (Default)	-
2 (Runtime Data)	1	Operating Mode	Unsigned32	Varies	-
	2	Message Rate	Unsigned32	Varies	Hz
	3	Serial Baud Rate	Unsigned32	Varies	Baud
	4	Built-In Test Mask	Unsigned32	0x07 (Default)	-
	5	BIT Gyro Movement	Unsigned32	0.0 (Default)	°/s
	6	BIT Accel Movement	Unsigned32	0.0 (Default)	g
	7	Minimum Temperature	Float32	RESERVED	-
	8	Maximum Temperature	Float32	RESERVED	-
	9	Clock	Float32	Varies	Hour
3 - 7	RESERVED				

[19] Bandwidth values specify both the Butterworth Filter cutoff frequency and the filter order with the following format: (CUTOFF.ORDER). For example, a 250 Hz cutoff frequency with a 2nd order filter would be (250.2). The maximum bandwidth setting is 350 Hz, and 600 Hz with VELOX® Plus.

Device Mode and Baud Rate

For the Mode and Baud Rate, the value of the coefficient parameter is defined as follows:

Bit	Name	Value
0 - 7	Mode	0=RESERVED 1=RESERVED 2=RESERVED 3=RESERVED 4=RESERVED 6=200 HZ Mode 7=100 HZ Mode 11=10 HZ Mode 12=RESERVED 13=500 HZ Mode 14=RESERVED 15=1000 HZ Mode 17=RESERVED 18=2500 HZ Mode 19=RESERVED 20=5000 HZ Mode
8 - 9	Resolution	00 = 16 bit 01 = 24 bit 10 = 32 bit 11 = RESERVED
10	Message Status Byte Decode	0=Normal, 1=Extended
11 - 15	Spare	0
16	RESERVED	RESERVED
17 18 19	Baud bit 0 Baud bit 1 Baud bit 2	000=115.2k 001=921.6k 010=1.5M 011=3.0M 100=6.0M 101=7.5M 110=RESERVED 111=RESERVED
20 - 31	Spare	0

10.1 Sensor Resolution

The mode of the device drives the effective resolution of the sensors based on internal sensor architecture of the device and sampling. The following tables document the resolution for both the gyros and accels for the various products using internal sampling. With External Sync sampling, only one sample is acquired with each rising edge of External Sync, so it is up to the application to do any additional filtering to improve resolution for their application.

The recommended LSB to use is based on application trade-off of model, mode, data rate, and latency requirements. If we remove latency, then the following LSB recommendations should be considered to ensure no loss of sensitivity in sensor reading:
Black – 16-bit LSB
Orange – 24-bit LSB
Green – 32-bit LSB

Effective Gyro Resolution					
		Gyro Range (°/s)			
		250	490	1000	2000
Output Data Rate (Hz)	100	0.000043	0.000084	0.000171	0.000341
	500	0.000095	0.000187	0.000381	0.000763
	1000	0.000135	0.000264	0.000539	0.001079
	2500	0.000213	0.000418	0.000853	0.001706
	5000	0.000302	0.000591	0.001206	0.002413
	10000	0.000426	0.000836	0.001706	0.003412

Figure 4: Effective gyro resolution.

Note:
Though the effective gyro resolution can be very small, the lower bound of the noise floor needs to be considered as well for true sensitivity considerations. Refer to the model data sheets for model specific noise floor limits.

Effective Accel Resolution (mg)								
		Accel Range (g)						
		2	10	15	40	65	98	131
Output Data Rate (Hz)	100	0.000341	0.001706	0.002559	0.006824	0.011089	0.016719	0.022348
	500	0.000763	0.003815	0.005722	0.015259	0.024796	0.037384	0.049973
	1000	0.001079	0.005395	0.008092	0.021579	0.035066	0.052869	0.070672
	2500	0.001706	0.008530	0.012795	0.034120	0.055444	0.083593	0.111742
	5000	0.002413	0.012063	0.018095	0.048253	0.078410	0.118219	0.158027
	10000	0.003412	0.017060	0.025590	0.068239	0.110889	0.167186	0.223484

Figure 5: Effective accel resolution.

Note:
Though the effective accel resolution can be very small, the lower bound of the noise floor needs to be considered as well for true sensitivity considerations. Refer to the model data sheets for model specific noise floor limits.

10.2 Baud Rates

The baud rate needs to be at least 20% higher than the message rate times the number of bits per message so that device may receive commands from the host. Here is a table that describes the relationship between baud rate and message rate (assuming IMU16 mode):

		Baud Rate						
		115200	921600	1.5M	3.0M	6.0M	7.5M	Bits/second
Data Rate (Hz)	100	Yes	Yes	Yes	Yes	Yes	Yes	19800
	200	Yes	Yes	Yes	Yes	Yes	Yes	39600
	500	Yes	Yes	Yes	Yes	Yes	Yes	99000
	1000	-	Yes	Yes	Yes	Yes	Yes	198000
	2500	-	Yes	Yes	Yes	Yes	Yes	495000
	5000	-	-	Yes	Yes	Yes	Yes	990000
	8000	-	-	-	Yes	Yes	Yes	1584000
	10000	-	-	-	Yes	Yes	Yes	1980000

Note that the device baud rates deviate slightly from the listed baud rates. This difference is extremely small, but it is important if system timing is critical in customer applications. Refer to the Technical Summary specific to your product for the baud rate variation over temperature.

Listed	**Actual**	**Percent Difference**
115200	115218	0.0156%
921600	923076	0.1602%
1.5 M	1500000	0%
3.0 M	3000000	0%
6.0 M	6000000	0%
7.5 M	7500000	0%

11 Appendix D - Using Glamr to See Message Bytes

Using the Glamr software included in the Software Development Kit (SDK), you can use “Show RX (decoded) msg bytes” to verify you have received messages. You can find the messages at the bottom of the window.

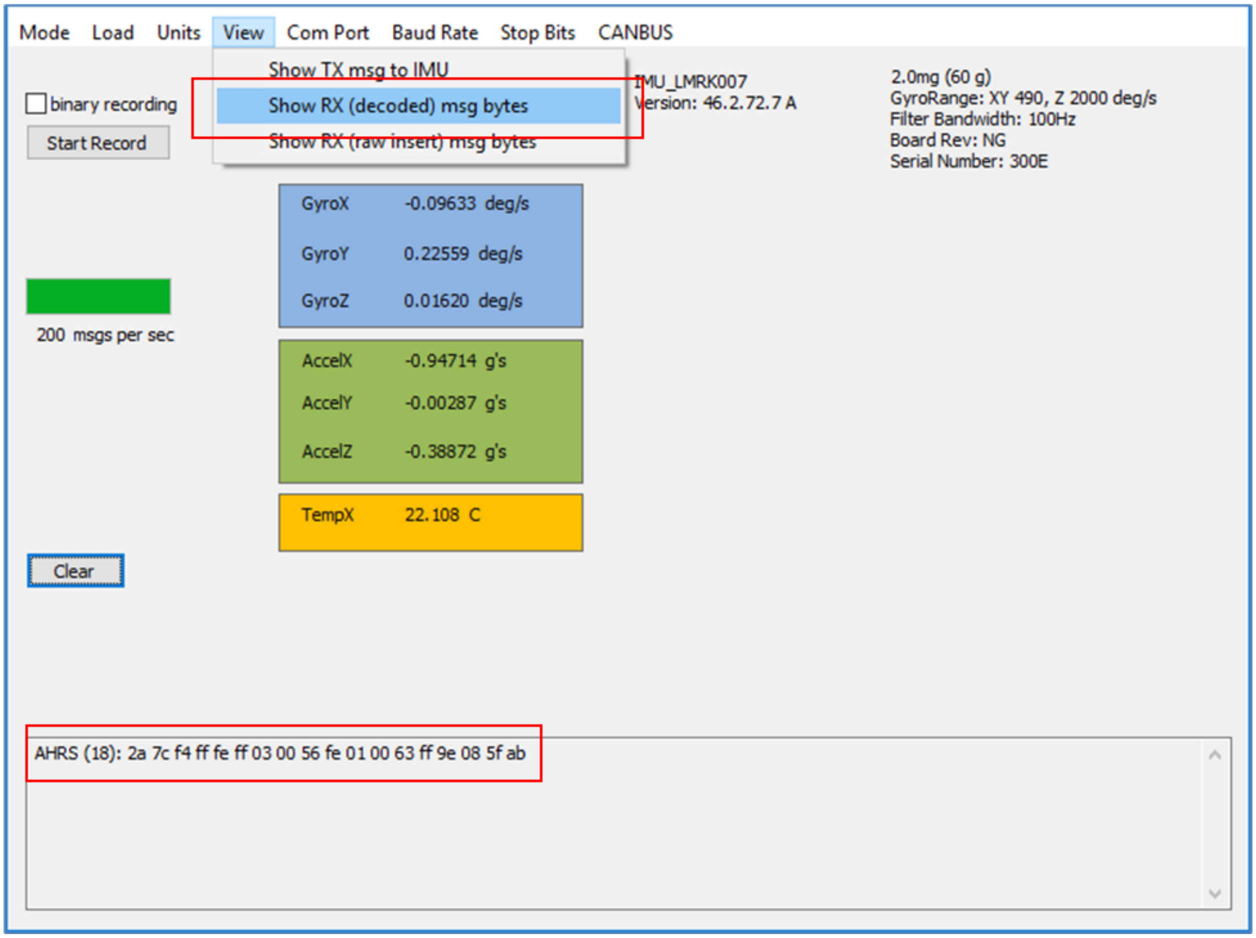


Figure 6: Show RX decode message.

You can use "Show RX (raw insert) msg bytes" to view the RX raw message. You can find the message at the bottom of the window. To view the whole message, you will have to scroll through the message box.

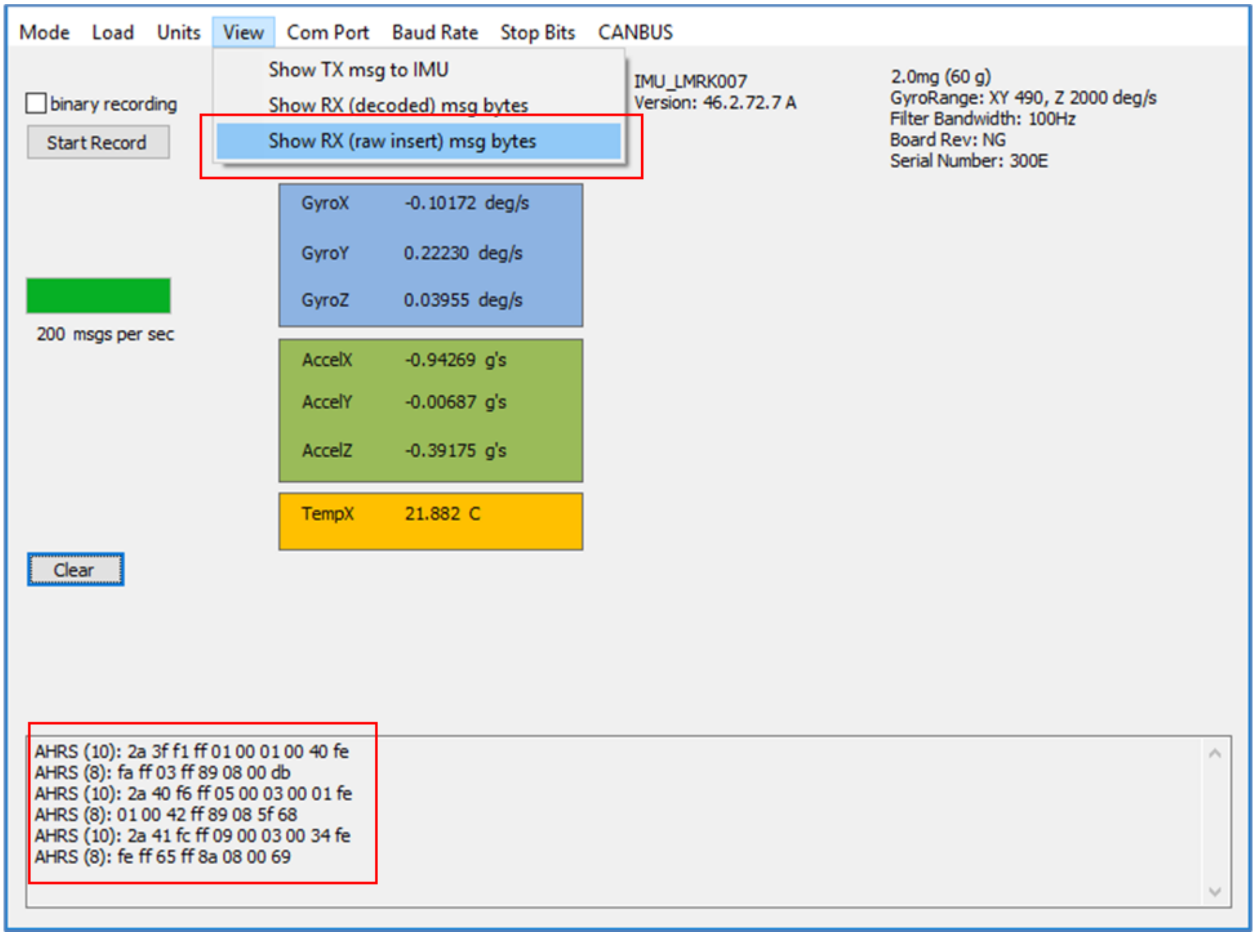


Figure 7: Show RX raw message.

You can use "Show TX msg to IMU" to verify host messages sent to the device. You can find the message at the bottom of the window. Notice the use of the UNLOCK byte (0xD4) before sending of the message. To view the whole message, you will have to scroll through the message box.

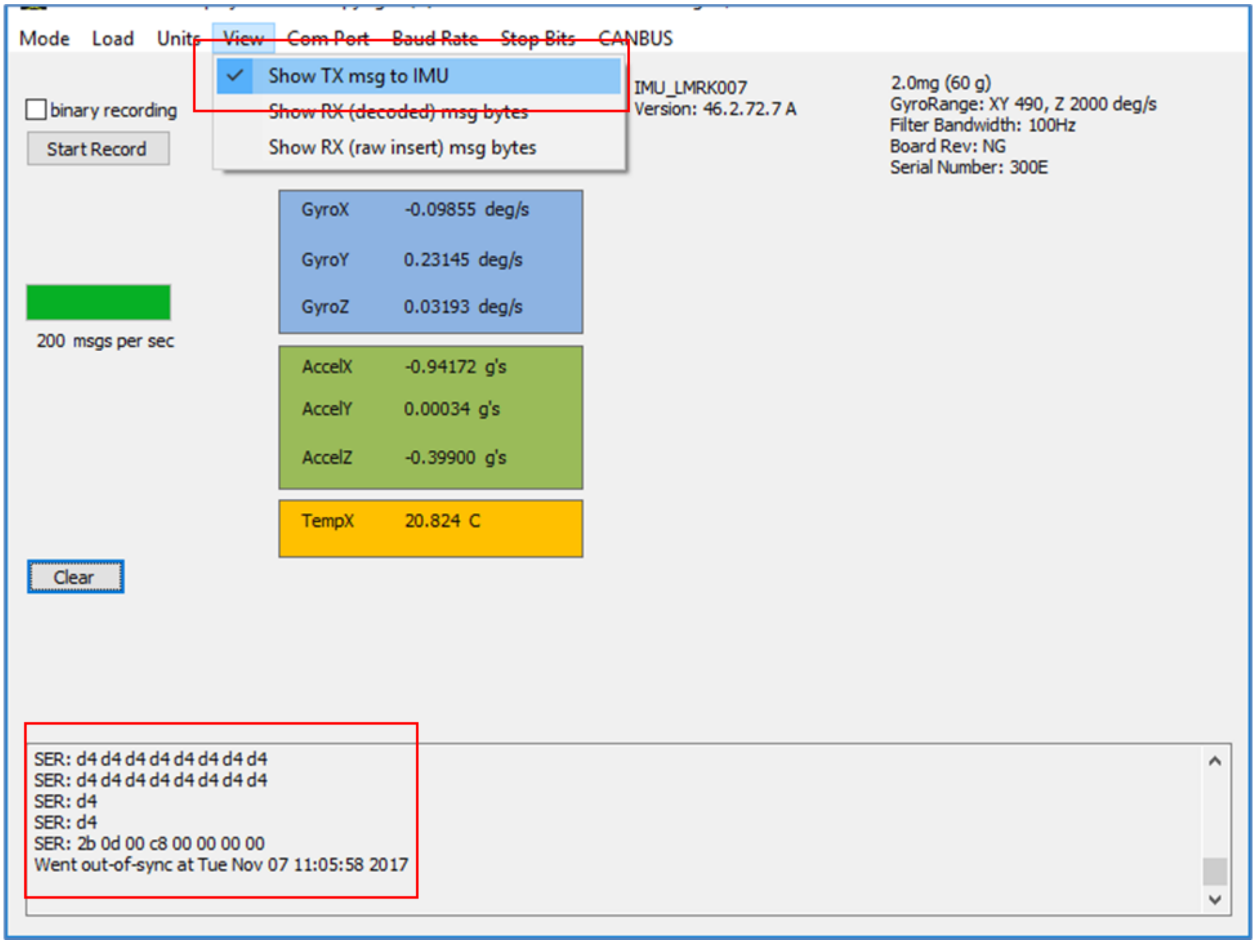


Figure 8: Show TX message.

12 Revision History

Rev	Date	Description	Page Number(s)
A	2-4-2021	Initial document creation.	-