# LORD USER MANUAL

## MV5-ML5 Sensors — J1939 Communications

### Compact, Ruggedized Attitude Reference and Inertial Measurement Units


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## Contents

# 1. Sensor Overview

The LORD Sensing M Series sensors bring a new level of precision to measurements of dynamic inclination, acceleration, and angular rate in challenging environments such as those encountered in heavy-duty construction, off-highway, agriculture, and trucking industries.

Designed specifically for CAN equipped applications, the M-Series sensors provide a choice of units.Select the MV5-AR for the most demanding environments, or the ML5-AR, with slightly reduced specifications, in more cost sensitive applications. Both units are rugged, high-performance devices.

Both the MV5-AR and ML5-AR utilize the power of a sophisticated Auto-Adaptive Extended Kalman Filter (EKF) to remove errors associated with vibration, sudden linear motions, and quake, resulting in a true reading of inclination under all conditions. The wide bandwidth, low noise accelerometer and 1000dps gyroscope allow accurate IMU measurements of the most extreme events, making it ideal for monitoring shock and vibration fatigue.

LORD Sensing's state-of-the-art temperature compensation and calibration assures error-free performance over the full operational temperature range.

The compact size, wide 4.5 to 36 V power range, IP68 / IP69K rating, and **CAN J1939 or CANopen communications interface options** make the MV5-AR and ML5-AR a single part solution for a full range of vehicle sizes and applications. **You must specify communications protocol at time of order.**

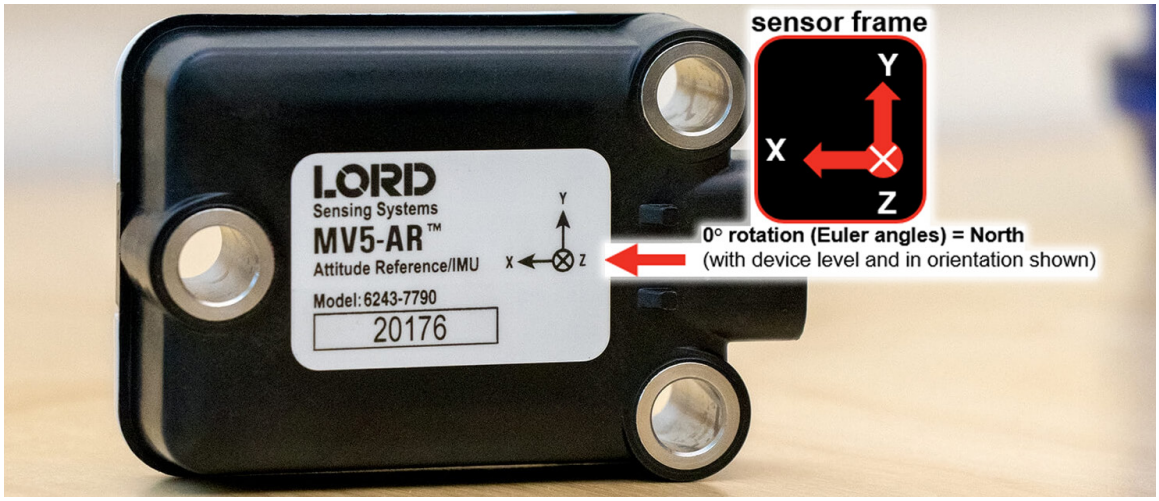



LORD SENSING MicroStrain

# 2. Installation

## 2.1 Installation

The sensor has three mounting holes for fastening with M8 (5/16") socket head cap screws, (hardware not included). The sensor can be mounted in any orientation, as required for the application. The axes are labeled on the face of the sensor for reference. When mounting requires the device to be rotated with respect to the vehicle or implement reference frame, the slope outputs may be adjusted into optimum measurement range using the device configuration commands in section 5. Note that rotation about the X axis is roll, and rotation about the Y axis is pitch.



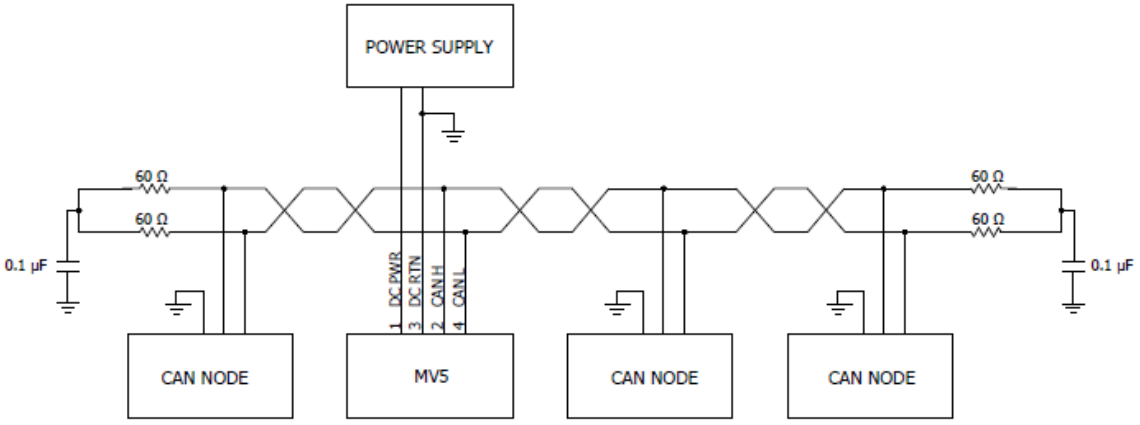

## 2.2 Sensor Calibration

All internal sensors in the M-Series are calibrated when the device is manufactured. Exposure to conditions beyond the operating specifications may cause permanent changes to the sensor characteristics and render the calibration ineffective. For example, if the sensor has been exposed to excessive shock beyond the rated g-force, performance may be compromised. Indications of internal sensor damage may be observed as excessive measurement offsets or drift when the sensor is in a neutral motionless position.

## 2.3 Temperature Calibration

All sensor conversion and calibration formulas include temperature compensation. All computed outputs and IMU sensor outputs are automatically adjusted for local temperature.

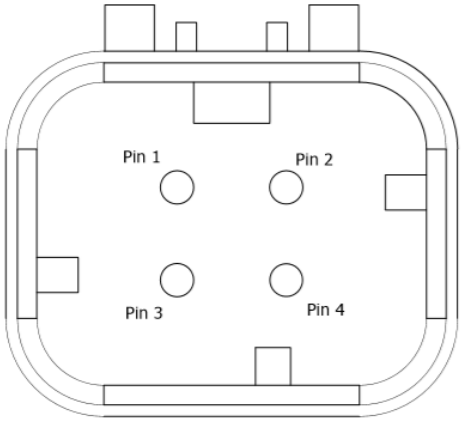
## 2.4 Cabling and Termination




LORD recommends split termination on both ends of the cable for optimum EMC performance.

Recommended mating connector shell: TE Connectivity 776487-1 or equivalent

## 2.5 Pinout

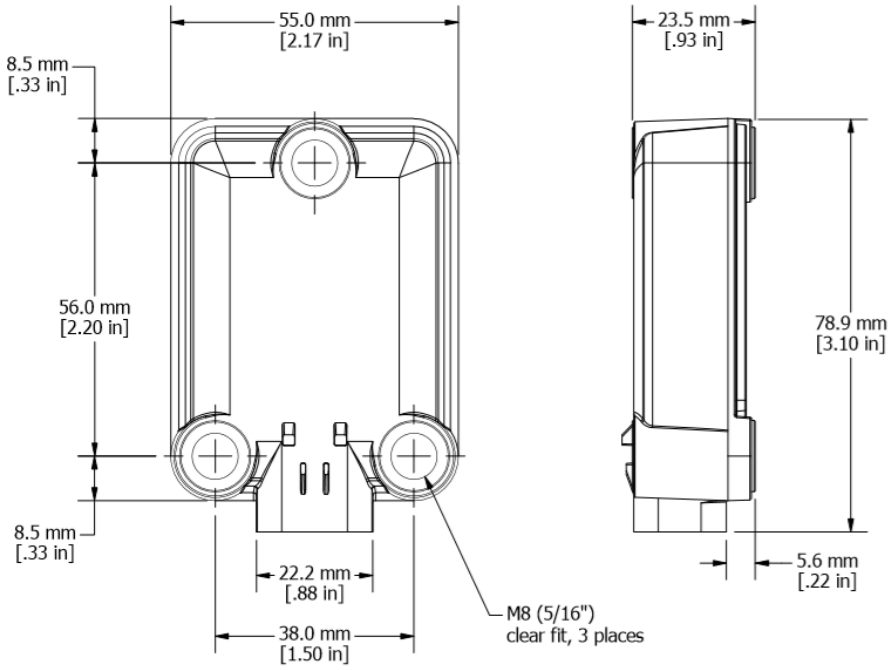



**Connector Termination**

| Pin | Description |
|---|---|
| 1 | DC Power |
| 2 | CAN High |
| 3 | DC Return |
| 4 | CAN Low |

Mating connector: AMPSEAL 16 Series gold plated 4 pin (available for purchase, contact sales.)

## 2.6 Dimensions



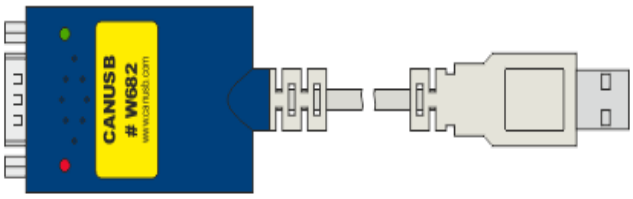
## 2.7 Connecting with CAN

For clients needing CAN connectivity from their computers, LORD Sensing can suggest two ways to begin.

Clients with existing CAN networks who wish to verify communications with a specific sensor may find this unit, from Peak-System GmbH useful. It comes complete with communications monitor software, PCAN-View. Full details and ordering information can be found at: peak-system.com/PCAN-USB. A startup cable kit (p/n 6212-3017) is available from LORD Sensing Sales (sensing_sales@lord.com). This includes a short CAN bus, global power supply, and connectors for power, sensor and dongle.

An alternative, and somewhat less expensive interface is manufactured by Lawicel-AB, in south Sweden. The CANUSB interface is a small dongle which provides instant CAN connectivity. It can be treated by software as a virtual COM port, with the FTDI USB drivers. Sample programs in C, C++, C#, VB6, Delphi and Linux can be found on their downloads page: http://www.can232.com/?page_id=75.

You can obtain it directly from Lawicel (CANUSB.com) where you will find a listing of their international distributors.




For your convenience, the CANUSB device can be purchased directly from LORD Sensing. (sensing_sales@LORD.com). Ask for P/N 6212-3014. This includes a startup kit, with a global power supply, and short, terminated CAN bus, connectorized for sensor, dongle, and power.

A J1939 configuration file (.DBC) can be downloaded:

www.microstrain.com/inertial/m-series. Select your model, and scroll down to downloads.

# 3. MV5-AR Technical Data

## 3.1 IMU Accelerometer Specifications (3 Axis)

| Characteristic | Minimum | Typical | Maximum | Unit |
|---|---|---|---|---|
| Measurement range | -20 | | -20 | g |
| Accel output range (PGN 61485) | -320 | | +320 | $m/s^2$ |
| Non-linearity | -0.04 | | +0.04 | % fs |
| Resolution | | 0.05 | | mg |
| Bias instability | -0.08 | | +0.08 | mg |
| Initial bias error | -0.004 | | +0.004 | g |
| Scale factor stability | -0.05 | | +0.05 | % |
| Noise density | | 85 | | $\mu g/\sqrt{Hz}$ |
| Alignment error | -0.05 | | +0.05 | % |
| Bandwidth | 1 | 40 default | 225 | Hz |
| Offset error over temperature | | 0.2 | | % |
| Gain error over temperature | | 0.05 | | % |
| Scale factor non-linearity (@ 25°C) | | 0.04 | 0.2 | % |
| IMU data output rate | 1 | 100 | 500 | Hz |

## 3.2 IMU Gyroscope Specifications (3 Axis)

| Characteristic | Minimum | Typical | Maximum | Unit |
|---|---|---|---|---|
| Measurement range | -1000 | | +1000 | °/sec |
| Gyro output range (PGN 61482) | -250 | | +250 | |
| Non-linearity | -0.06 | | +0.06 | % fs |
| Resolution | | <0.003 | | °/sec |
| Bias instability | | 8 | | °/hr |
| Initial bias error | -0.1 | | +0.1 | °/sec |
| Scale factor stability | -0.05 | | +0.05 | % |
| Noise density | | 0.0075 | | $°/sec\sqrt{Hz}$ |
| Alignment error | -0.05 | | +0.05 | % |
| Bandwidth | 1 | 40 default | 500 | Hz |
| Offset error over temperature | | 0.1 | | % |
| Gain error over temperature | | 0.1 | 0.4 | % |
| Scale factor non-linearity (@ 25°C) | | 0.04 | 0.15 | % |
| IMU data output rate | 1 | 100 | 100 | Hz |

### 3.3 Attitude (pitch and roll) Output Specifications

| Characteristic | Minimum | Typical | Maximum | Unit |
|---|---|---|---|---|
| **Accuracy** | | ±0.2 | | rms deg |
| **EKF update rate** | | 500 | | Hz |
| **Pitch** | -90 | - | +90 | deg |
| **Roll** | -180 | - | +180 | deg |
| **Resolution** | | 0.05 | | deg |
| **Settling time** | | 5 | 200 | mSec |
| **Repeatability** | | 0.5 | | deg |
| **Data output rate** | 1 | 100 default | 500 | Hz |

### 3.4 System Interface

| Characteristic | Parameter |
|---|---|
| **Communication** | CAN 250 kb/s |
| **Protocol** | J1939 |
| **Connector** | AMPSEAL 16 receptacle, 4 Pin, gold plated pins |
| **CANH/CANL Operating Common-Mode Range** | -7V to +12V |
| **CANH/CANL Absolute Maximum Rating** | ±36V |
| **Short Circuit Protection** | All pins, automatic restart |
| **Start-up time: IMU** | 1 second |
| **Start-up time: Slope (EKF)** | 5 seconds |

### 3.5 Power Supply

| Characteristic | Minimum | Nominal | Maximum |
|---|---|---|---|
| **Operating Supply Voltage Range** | 4.5V | 5V (regulated),<br>or 12V or 24V (vehicle power) | 36V |
| **Power consumption (all voltages)** | | 625mW | |
| **Reverse Voltage Limits** | **-60V absolute max steady-state**<br>-15mA max clamped steady-state current if exceeding -60V<br>-15.5A max clamped brief surge current if exceeding -60V | | |
| **Overvoltage Limits** | **+40V absolute max steady-state**<br>+50mA max clamped steady-state current if exceeding +40V<br>+114A max clamped brief surge current if exceeding +40V | | |

### 3.6 Environmental

| Characteristic | Parameter |
|---|---|
| **Operating temperature** | -40°C to +85°C |
| **Storage temperature** | -40°C to +125°C |
| **Vibration (Random)** | MIL-STD-202G, , Method 214A, Test Condition 1-B, 24 hrs/axis |
| **Vibration (Sweep)** | J1455 Appendix A 10-2000Hz, 10 g Peak, 10hr/octave/axis |
| **Ingress protection** | IP68 (Immersion), IP69K (Pressure Wash) |
| **Thermal shock** | SAE J1455 10X |
| **Salt spray** | MIL-STD-202G, Method 101E Condition A (96 hours) |
| **Hot dunk** | 5X, 30 mins @ 85C, 30 mins @ ice bath, operating |
| **UV** | Stabilized Polymer |
| **Mechanical shock (Drop)** | 1m on to concrete surface 3x, J1455 |
| **Mechanical shock (Operating)** | 50g, 11ms 1/2sine, 3X direction, 18 total, MIL STD 202, M213 |

## 3.7 EMC & Electrical Compliance Standards

| Characteristic | Standard | Test Levels |
|---|---|---|
| **Radiated Immunity: ALSE** | ISO 11452-5:2004 | 200 V/m<br>200 MHz to 3.2 GHz |
| **Radiated Immunity: Bulk Current Injection** | ISO 11452-5:2002 | 200mA<br>1 to 400 MHz |
| **Radiated Immunity: Strip line** | ISO 11452-5:2002 | 200mA<br>10 kHz to 400 MHz |
| **Radiated emissions** | CISPR 25 ED. 4.0: 2016 | 150 kHz to 2.5 GHz,<br>Class 3 and 5 |
| **Conducted emissions** | CISPR 25 ED. 4.0: 2016 | 150 kHz to 88 MHz,<br>Class 5 |
| **Mutual coupling** | ISO 7637-2: 2011 Section 5.6.3 | Pulses 3a and 3b |
| **ESD direct contact discharge** | ISO 10605 | 8kV |
| **ESD air discharge** | ISO 10605 | 15KV |
| **Superimposed AC Voltage** | ISO 16750-2: 2010, Section 4.4 | 12V, 4Vp-p 24V,<br>10V p-p |
| **Starting Profile** | ISO 16750-2: 2010 | 12V, Table3, I-IV 24V,<br>Table 4, I-III |
| **Inducted EM Noise on Signal lines** | ISO 7637-3:2016 | CCC/ICC/DCC<br>methods |

## 3.8 Physical Specifications

| Characteristic | Parameter |
|---|---|
| **Dimensions** | L 78.9 mm x W 55.0 mm x H 23.5 mm |
| **Weight** | 110.5 grams |
| **Enclosure material** | PBT Thermoplastic, Reinforced |
| **Ingress protection** | IP68, IP69K |
| **MTBF** | 826,440 hrs Telcordia SR332 (issue 3) |
| **Mounting** | 3 x M8 (5/16") (user supplied)<br>Installation torque 20 ±2 Nm (14.75 ± 1.5 lb-ft) |
| **Regulatory compliance** | RoHS, REACH, CE |

# 4. ML5-AR Technical Data

## 4.1 IMU Accelerometer Specifications (3 Axis)

| Characteristic | Minimum | Typical | Maximum | Unit |
|---|---|---|---|---|
| Measurement range | -8 | | +8 | g |
| Output range | -320 | | +320 | $m/s^2$ |
| Non-linearity | -.08 | | +.08 | % fs |
| Resolution | | 0.05 | | mg |
| Bias instability | -.08 | | +.08 | mg |
| Initial bias error | -.008 | | +.008 | g |
| Scale factor stability | -.08 | | +.08 | % |
| Noise density | | 120 | | $\mu g/\sqrt{Hz}$ |
| Alignment error | -0.1 | | +0.1 | % |
| Bandwidth | 1 | 40 default | 225 | Hz |
| Offset error over temperature | | 0.2 | | % |
| Gain error over temperature | | 0.05 | | % |
| Scale factor non-linearity (@ 25°C) | | 0.1 | 0.2 | % |
| IMU data output rate | 1 | 100 | 100 | Hz |

## 4.2 IMU Gyroscope Specifications (3 Axis)

| Characteristic | Minimum | Typical | Maximum | Unit |
|---|---|---|---|---|
| Measurement range | -1000 | | +1000 | °/sec |
| Output range | -250 | | +250 | |
| Non-linearity | -0.06 | | +0.06 | % fs |
| Resolution | | <0.003 | | °/sec |
| Bias instability | | 8 | | °/hr |
| Initial bias error | -0.1 | | +0.1 | °/sec |
| Scale factor stability | -0.05 | | +0.05 | % |
| Noise density | | 0.0075 | | $°/sec\sqrt{Hz}$ |
| Alignment error | -0.05 | | +0.05 | % |
| Bandwidth | 1 | 40 default | 500 | Hz |
| Offset error over temperature | | 0.1 | | % |
| Gain error over temperature | | 0.1 | 0.4 | % |
| Scale factor non-linearity (@ 25°C) | | 0.04 | 0.15 | % |
| IMU data output rate | 1 | 100 | 100 | Hz |

## 4.3 Attitude (pitch and roll) Output Specifications

| Characteristic | Minimum | Typical | Maximum | Unit |
|---|---|---|---|---|
| **Accuracy** | | ±0.5 | | rms deg |
| **EKF update rate** | | 100 | | Hz |
| **Pitch** | -85 | - | +85 | deg |
| **Roll** | -180 | - | +180 | deg |
| **Resolution** | | 0.05 | | deg |
| **Settling time** | | 5 | 200 | mSec |
| **Repeatability** | | 0.5 | | deg |
| **Data output rate** | 1 | 100 default | 100 | Hz |

## 4.4 System Interface

| Characteristic | Parameter |
|---|---|
| **Communication** | CAN 250 kb/s |
| **Protocol** | J1939 |
| **Connector** | AMPSEAL 16 receptacle, 4 Pin, gold plated pins |
| **CANH/CANL Operating Common-Mode Range** | -7V to +12V |
| **CANH/CANL Absolute Maximum Rating** | ±36V |
| **Short Circuit Protection** | All pins, automatic restart |
| **Start-up time: IMU** | 1 second |
| **Start-up time: Slope (EKF)** | 5 seconds |

## 4.5 Power Supply

| Characteristic | Minimum | Nominal | Maximum |
|---|---|---|---|
| **Operating Supply Voltage Range** | 4.5V | 5V (regulated),<br>or 12V or 24V (vehicle power) | 36V |
| **Power consumption (all voltages)** | | 360 mW nominal | |
| **Reverse Voltage Limits** | **-60V absolute max steady-state**<br>-15mA max clamped steady-state current if exceeding -60V<br>-15.5A max clamped brief surge current if exceeding -60V | | |
| **Overvoltage Limits** | **+40V absolute max steady-state**<br>+50mA max clamped steady-state current if exceeding +40V<br>+114A max clamped brief surge current if exceeding +40V | | |

## 4.6 Environmental

| Characteristic | Parameter |
|---|---|
| **Operating temperature** | -40°C to +85°C |
| **Storage temperature** | -40°C to +125°C |
| **Vibration (Random)** | MIL-STD-202G, , Method 214A, Test Condition 1-B, 24 hrs/axis |
| **Vibration (Sweep)** | J1455 Appendix A 10-2000Hz, 10 g Peak, 10hr/octave/axis |
| **Ingress protection** | IP68 (Immersion), IP69K (Pressure Wash) |
| **Thermal shock** | SAE J1455 10X |
| **Salt spray** | MIL-STD-202G, Method 101E Condition A (96 hours) |
| **Hot dunk** | 5X, 30 mins @ 85C, 30 mins @ ice bath, operating |
| **UV rating** | Stabilized polymer |
| **Mechanical shock (Drop** | 1m on to concrete surface 3x, J1455 |
| **Mechanical shock (Operating)** | 50g, 11ms 1/2sine, 3X direction, 18 total, MIL STD 202, M213 |

## 4.7 EMC and Electrical Compliance Standards

| Characteristic | Standard | Test Levels |
|---|---|---|
| **Radiated Immunity: ALSE** | ISO 11452-5:2004 | 200 V/m<br>200 MHz to 3.2 GHz |
| **Radiated Immunity: Bulk Current Injection** | ISO 11452-5:2002 | 200mA<br>1 to 400 MHz |
| **Radiated Immunity: Strip line** | ISO 11452-5:2002 | 200mA<br>10 kHz to 400 MHz |
| **Radiated emissions** | CISPR 25 ED. 4.0: 2016 | 150 kHz to 2.5 GHz,<br>Class 3 and 5 |
| **Conducted emissions** | CISPR 25 ED. 4.0: 2016 | 150 kHz to 88 MHz,<br>Class 5 |
| **Mutual coupling** | ISO 7637-2: 2011 Section 5.6.3 | Pulses 3a and 3b |
| **ESD direct contact discharge** | ISO 10605 | 8kV |
| **ESD air discharge** | ISO 10605 | 15KV |
| **Superimposed AC Voltage** | ISO 16750-2: 2010, Section 4.4 | 12V, 4Vp-p 24V,<br>10V p-p |
| **Starting Profile** | ISO 16750-2: 2010 | 12V, Table3, I-IV 24V,<br>Table 4, I-III |
| **Induced EM Noise on Signal lines** | ISO 7637-3:2016 | CCC/ICC/DCC<br>methods |

## 4.8 Physical Specifications

| Characteristic | Parameter |
|---|---|
| **Dimensions** | L 78.9 mm x W 55.0 mm x H 23.5 mm |
| **Weight** | 110.5 grams |
| **Enclosure material** | PBT Thermoplastic, Reinforced |
| **Ingress protection** | IP68, IP69K |
| **MTBF** | 826,440 hrs; Telcordia SR332 (issue 3) |
| **Mounting** | 3 x M8 (5/16") (user supplied)<br>Installation torque 20 ±2 Nm (14.75 ± 1.5 lb-ft |
| **Regulatory compliance** | RoHS, REACH, CE |

# 5. CAN Messages and Communication

## 5.1 CAN J1939 Protocol Information

Data supplied by the sensors is communicated through the CAN J1939 communications interface.

To learn more about SAE J1939 communication standards, go to: SAE J1939 Standards.

Download a J 1939 configuration file (.DBC) from: www.microstrain.com/inertial/m-series.

Select your model, and scroll down to downloads.

### 5.1.1 CAN J1939 Protocol Information

| 29 BIT IDENTIFIER | | | |
|---|---|---|---|
| **Name** | **Bits** | **Bit position** | **Description** |
| **Priority** | 3 | 29..27 | 0 through 7, lower is higher priority. |
| **R** | 1 | 26 | Reserved (default 0) |
| **DP** | 1 | 25 | Data Page (default 0) |
| **PDU Format** | 8 | 24..17 | PDU1 format if < 0xF0 (240). Otherwise PDU2 format. |
| **PDU Specific** | 8 | 16..9 | Used for PDU2 format PGNs. Destination is always broadcast (0xFF). |
| **Source** | 8 | 8..1 | Source address of MV5 |
| **8 BYTE DATA FIELD** | | | |
| **Name** | **Bits** | **Bit position** | **Description** |
| **BYTE 8** | 8 | 8..1 | Data (PDU specific) |
| **BYTE 7** | 8 | 8..1 | Data (PDU specific) |
| **BYTE 6** | 8 | 8..1 | Data (PDU specific) |
| **BYTE 5** | 8 | 8..1 | Data (PDU specific) |
| **BYTE 4** | 8 | 8..1 | Data (PDU specific) |
| **BYTE 3** | 8 | 8..1 | Data (PDU specific) |
| **BYTE 2** | 8 | 8..1 | Data (PDU specific) |
| **BYTE 1** | 8 | 8..1 | Data (PDU specific) |

## 5.2 Standard Broadcast Data

These PGNs are standard default data broadcast by device at 100Hz (interval 10 ms). The channels may be disabled individually. The broadcast intervals are programmable individually from 2 to 500 ms. To decode a given field, extract the relevant bits, multiply by the resolution, and add the offset. The ranges given are protocol limitations only and do not necessarily reflect the true sensor ranges, which may exceed the protocol range.

Many of these PGNs contain figures of merit, as specified by the J1939 standard. The values are as follows:

| Value | Definition |
|---|---|
| **0** | Output is functioning normally. |
| **1** | Output quality may be degraded. |
| **2** | Error condition. |
| **3** | Figure of merit information is not available. |

### 5.2.1 Angular Rate PGN 61482 (0xF02A)

| | | | | | |
|---|---|---|---|---|---|
| **Description** | Transmit Angular Rate Sensor Data (3 axis 360°) Right-handed axis system, Z axis points down.<br>The range and resolution given below is the theoretical range and resolution allowed by the format. See the device specifications for the actual measurement range and resolution. Note that the internal measurement range may exceed the range available from this message format. | | | | |
| **Example** | Pitch rate = Payload [0..1] * (1/128.0) -250 | | | | |
| **SPN** | Bit position (Byte.bit) | Length | Resolution | Offset | Range |
| **Pitch Rate** | Bytes 1-2 | 2 Bytes | 1/128 °/s/bit | -250 °/s | -250 to 250.992° |
| **Roll Rate** | Bytes 3-4 | 2 Bytes | 1/128 °/s/bit | -250 °/s | -250 to 250.992° |
| **Yaw Rate** | Bytes 5-6 | 2 Bytes | 1/128 °/s/bit | -250 °/s | -250 to 250.992° |
| **Pitch Rate figure of merit1** | 7.1-7.2 | 2 bits | 0 = Functional<br>1 = Degraded<br>2 = Error<br>3 = Not available | | |
| **Roll Rate figure of merit1** | 7.3-7.4 | 2 bits | | | |
| **Yaw Rate figure of merit1** | 7.5-7.6 | 2 bits | | | |
| **Not Implemented** | 7.7-7.8 | 2 bits | N/A | | |
| **Not Implemented** | Byte 8 | 1 Byte | N/A | | |

| 5.2.2 Acceleration PGN 61485 (0xF02D) | | | | | |
|---|---|---|---|---|---|
| **Description** | Transmit Acceleration Sensor Data (2 axis -pitch, roll, status). Right-handed axis system, Z axis points up.<br>The range and resolution given below is the theoretical range and resolution allowed by the format. See the device specifications for the actual measurement range and resolution. | | | | |
| **Example** | Pitch rate = Payload [0..1] * (1/100) -320 | | | | |
| **SPN** | Bit position (Byte.bit) | Length | Resolution | Offset | Range |
| **Lateral Accel. (Y)** | Bytes 1-2 | 2 Bytes | 0.01 m/s2/bit | -320 m/s2 | -320 to +322.55 $m/s^2$ |
| **Longitudinal Accel. (X)** | Bytes 3-4 | 2 Bytes | 0.01 m/s2/bit | -320 m/s2 | -320 to +322.55 $m/s^2$ |
| **Vertical Accel. (Z)** | Bytes 5-6 | 2 Bytes | 0.01 m/s2/bit | -320 m/s2 | -320 to +322.55 $m/s^2$ |
| **Lateral Accel. figure of merit1** | 7.1-7.2 | 2 bits | 0 = Functional<br>1 = Degraded<br>2 = Error<br>3 = Not available | | |
| **Longitudinal Accel. figure of merit1** | 7.3-7.4 | 2 bits | | | |
| **Vertical Accel. figure of merit1** | 7.5-7.6 | 2 bits | | | |
| **Not Implemented** | 7.7-7.8 | 2 bits | N/A | | |
| **Not Implemented** | Byte 8 | 1 Byte | N/A | | |

| 5.2.3 Slope Sensor PGN 61481 (0xF029) | | | | | |
|---|---|---|---|---|---|
| **Description** | Transmit Extended Slope Sensor Data (3 axis 60°) Right-handed axis system, Z axis points down.<br>The range and resolution given below is the theoretical range and resolution allowed by the format. See the device specifications for the actual measurement range and resolution. | | | | |
| **SPN** | Bit position (Byte.bit) | Length | Resolution | Offset | Range |
| **Pitch Angle** | Bytes 1-3 | 3 Bytes | 1/32768 °/bit | -250° | -250 to 250.992° |
| **Roll Angle** | Bytes 4-6 | 3 Bytes | 1/32768 °/bit | -250° | -250 to 250.992° |
| **Pitch Compensated2** | Bytes 7.1-7.2 | 2 bits | 0=Uncompensated<br>1=Compensated | | |
| **Pitch Angle figure of merit1** | 7.3-7.4 | 2 bits | 0 = Functional<br>1 = Degraded<br>2 = Error<br>3 = Not available | | |
| **Roll Compensated2** | 7.5-7.6 | 2 bits | 0=Uncompensated<br>1=Compensated | | |
| **Roll Angle figure of merit1** | 7.7-7.8 | 2 bits | 0 = Functional<br>1 = Degraded<br>2 = Error<br>3 = Not available | | |
| **Not Implemented** | Byte 8 | 1 Byte | N/A | | |

## 5.3 Standard Commands

The PGNs in this section are standard commands that may be issued to the device as defined in the SAE J1939 standard documents.

**Note:** Examples assume a source ID of 0x99 and a target ID of 0xFC.

| 5.3.1 Request Information PGN 59904 (0xEA00) | | | | | |
|---|---|---|---|---|---|
| **Description** | Request the specified PGN be transmitted by the device. The PGN's that may be requested with this PGN are: **39680**, **65234**, **65242**, **64965**, **60928**, **65259**, **45312**, **45568**, **45824**, **46592**, **49152**. All others will be Nacked with a **59392** message. | | | | |
| **Example** | 0x18 EA FC 99 00 B6 00 (requests packet 0xB600 (PGN 46592)) | | | | |
| **SPN** | Bit position (Byte.bit) | Length | Resolution | Offset | Range |
| **PGN Requested** | 1 | 3 Bytes | N/A | N/A | N/A |

| 5.3.2 ACKM PGN 59392 (0xE800) | | | |
|---|---|---|---|
| **Description** | Sent by device in response to PGN 59904 Request and the settings PGNs in Section 7. Ack type will be NACK if requested PGN is not recognized or unable to send, or ACK if successful. | | |
| **Example** | 0x00 FF FF FF 99 00 B6 00 (ACK) | | |
| **SPN** | Bit position (Byte.bit) | Length | Notes |
| **Ack type** | 1 | 1 Byte | 0=ACK, 1=NACK, 2=Access Denied, 3=Device Busy |
| **Group Function** | 2 | 1 Byte | Unused, always 0xFF |
| **Reserved** | 3 | 1 Byte | |
| **Reserved** | 4 | 1 Byte | |
| **Destination** | 5 | 1 Byte | Destination address |
| **PGN** | 6 | 3 Bytes | PGN of command being ACK'd. |

| 5.3.3 Commanded Test PGN 58112 (0xE300) | | | |
|---|---|---|---|
| **Description** | Initiates the built-in test (J1939 diagnostic message "DM7"). The response will come in PGN 65232 (J1939 diagnostic message "DM8") | | |
| **Example** | 0x18 E3 FC 99 01 FF FF FF FF FF FF FF (requests packet 0xFED0 (PGN 65232)) | | |
| **SPN** | Bit position (Byte.bit) | Length | Notes |
| **Test ID** | 1 | 1 Byte | Test Identifier, must be 1 |
| **SPN Low** | 2 | 2 Bytes | Unused, set to 0xFF |
| **FMI** | 4.1 | 5 Bits | Unused, set to 0x1F |
| **SPN High** | 4.6 | 3 Bits | Unused, set to 0x7 |
| **Reserved** | 5 | 4 Bytes | Unused, set to 0xFFFFFFFF |

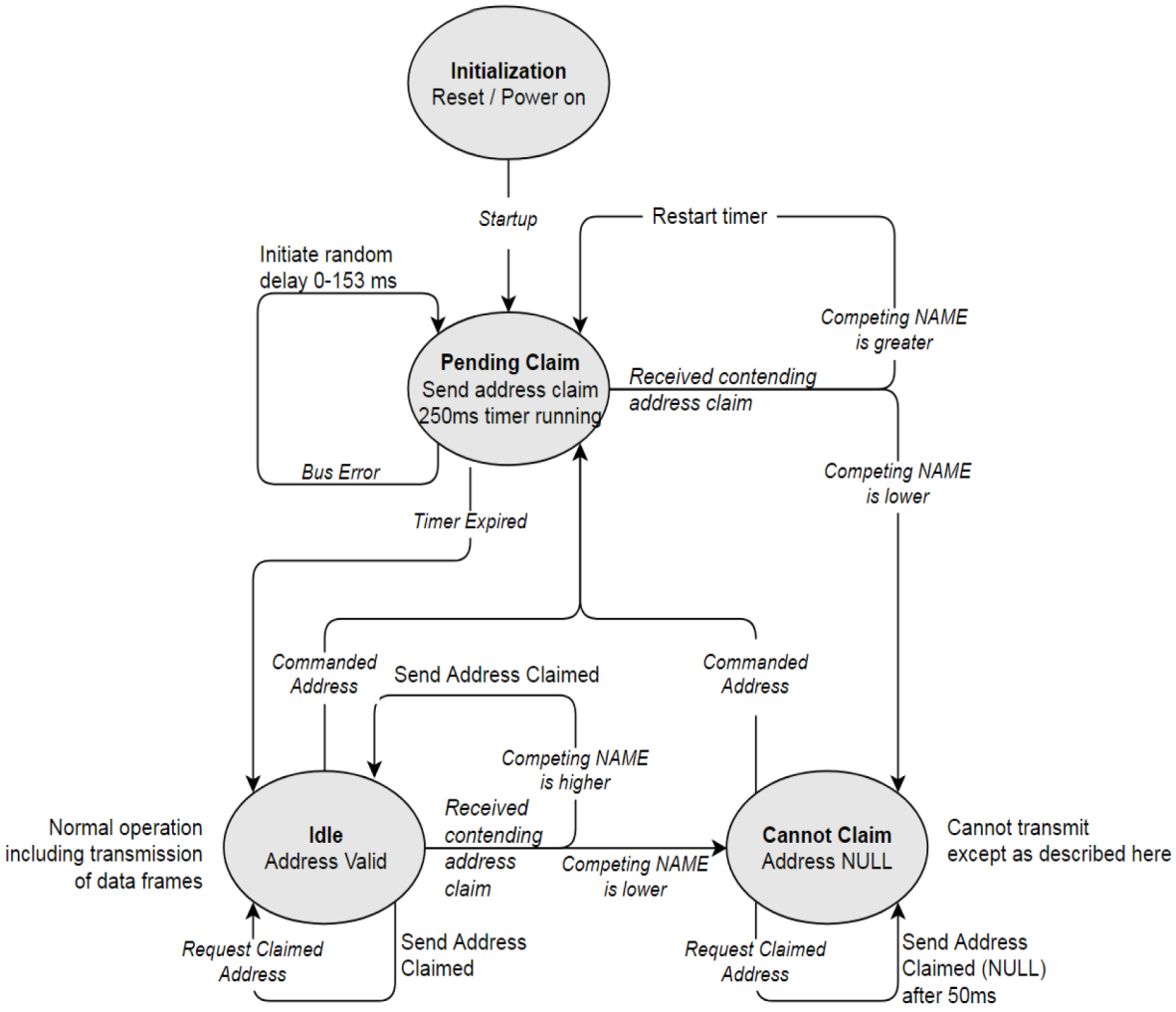
| 5.3.4 Commanded Test Result PGN 65232 (0xFED0) | | | | |
|---|---|---|---|---|
| **Description** | Returns the test pass/fail status (J1939 diagnostic message "DM8") requested using 58112 (J1939 diagnostic message "DM7"). | | | |
| **Example** | 0x18 FE D2 FC 01 FF 00 00 00 00 00 00 | | | |
| **SPN** | Bit position (Byte.bit) | Length | Range | Notes |
| **Test ID** | 1 | 1 Byte | N/A | Always 1 |
| **Component ID** | 2 | 1 Byte | N/A | Always 0xFF |
| **Test Result** | 3 | 2 Bytes | 0 - 65535 | Pass if this is between min and max values (0 is passing) |
| **Maximum** | 5 | 2 Bytes | 0- 65535 | Always 0 |
| **Minimum** | 7 | 2 Bytes | 0- 65535 | Always 0 |

| 5.3.5 Supported Tests PGN 65234 (0xFED2) | | | |
|---|---|---|---|
| **Description** | Reports 1 test supported (the BIT test) (J1939 diagnostic message "DM10"). This PGN is transmitted by the device upon request (use PGN 0xEA00 to request). | | |
| **Example** | 0x18 FE D2 FC 80 00 00 00 00 00 00 00 | | |
| **SPN** | Bit position (Byte.bit) | Length | Notes |
| **Tests** | 1 | 8 Bytes | Bitfield of supported tests. Least-significant bit comes first in each byte. Always 0x0000000000000080 (i.e. test #1 is supported) |

| 5.3.6 Commanded Address PGN 65240 (0xFED8) | | | |
|---|---|---|---|
| **Description** | Restart address claim procedure using the specified address. Saved to non-volatile memory. Must be sent using 9-Byte BAM (Broadcast announcement message). | | |
| **Example** | | | |
| **SPN** | Bit position (Byte.bit) | Length | Notes |
| **Name** | 1 | 8 Bytes | J1939 Device NAME |
| **Address** | 8 | 1 Byte | New source address. Cannot be 0xFF (broadcast address) or 0xFE (NULL address). |

| 5.3.7 Address Claim PGN 60928 (0xEE00) | | |
|---|---|---|
| **Description** | Transmitted by J1939 ECUs including the MV5 after:<br>• Every power on<br>• A request for Address Claimed command<br>• A re-claim situation when receiving an Address Claimed message with the same Source Address<br>• Programming a new Source Address<br>• Programming a new NAME<br>The PGN is used to compare NAME priority with devices with same address to facilitate address claiming (See Address Claim Logic diagram). | |
| **Example** | 0x18 EE FF FC 00 00 20 47 00 91 00 20 | |
| **SPN** | Length | Notes |
| **J1939 NAME** | 8 Bytes | J1939 NAME value stored on device.<br>Lower valued names have higher priority. |

### 5.3.8 Address Claim Procedure



| 5.3.9 Stop/Start Broadcast PGN 57088 (0xDF00) | | | | |
|---|---|---|---|---|
| **Description** | Suspends or resumes transmission of data. | | | |
| **Example** | 0x18 DF FC 99 3F FF FF FF 00 00 FF FF FF (stop indefinitely)<br>0x18 DF FC 99 7F FF FF FF FF FF FF FF FF (start immediately)<br>0x18 DF FC 99 3F FF FF FF FF 00 08 FF FF (Stop for 2 seconds)<br>0x18 DF FC 99 FF FF FF FF 0F 00 10 FF FF (Set stop duration to 4 seconds) | | | |
| **SPN** | Bit position (Byte.bit) | Length | Resolution | Notes |
| **J1939 #1** | 1.1 | 2 Bits | 0=STOP<br>1=START<br>2=Reserved<br>3=No Change | Interpreted |
| **J1922** | 1.3 | 2 Bits | | Ignored |
| **J1587** | 1.5 | 2 Bits | | Ignored |
| **Current Link** | 1.7 | 2 Bits | | Interpreted |
| **Other** | 2.1 | 2 Bits | | Ignored |
| **J1850** | 2.3 | 2 Bits | | Ignored |
| **ISO 9141** | 2.5 | 2 Bits | | Ignored |
| **J1939 #2** | 2.7 | 2 Bits | | Ignored |
| **J1939 #4** | 3.1 | 2 Bits | | Ignored |
| **Proprietary #2** | 3.3 | 2 Bits | | Ignored |
| **Proprietary #1** | 3.5 | 2 Bits | | Ignored |
| **J1939 #3** | 3.7 | 2 Bits | | Ignored |
| **Suspend** | 4.1 | 4 bits | 0x0=All<br>0x1=Some<br>0x2=All (temporary)<br>0x3=Some (temporary)<br>0x4-0xD=Reserved<br>0xE=Resume<br>0xF=N/A | Not currently implemented. For future compatibility use 0xF. |
| **Hold** | 4.5 | 4 bits | 0x0=Hold All Devices<br>0x1=Hold Modified Devices<br>0x2-0xE=Reserved<br>0xF=N/A | Ignored unless set to 0x0 and the device was already stopped. In this case the suspend duration is updated even if No Change was specified for the current link. |
| **Duration** | 5 | 2 bytes | Duration of effect in ms. | Not currently implemented (always indefinite). Use 0xFFFF for future compatibility. |
| **Reserved** | 7 | 2 bytes | reserved | Set to 0xFFFF |

| 5.3.10 Proprietary Messaging Information PGN 39680 (0x9B00) | | | | |
|---|---|---|---|---|
| **Description** | Indicates devices usage of the PropA, PropA2, and PropB messages. Allows ECUs to determine if they know this device lingo or not. Vendor ID 11 bits, Protocol 21 bits = “ue” (LORD internal protocol).<br>This PGN can be requested from the device (use PGN 0xEA00 to request). | | | |
| **Example** | 0x18 9B 99 FC 39 02 65 75 00 00 00 00 | | | |
| **SPN** | Bit position (Byte.bit) | Length | Value | Notes |
| **Manufacturer** | 1.1 | 11 Bits | Always 569 (0x0239) | LORD Sensing ID |
| **Protocol** | 2.3 | 21 Bits | Manufacturer-specific protocol ID | Split into version and ID fields below |
| **Protocol.version** | 2.3 | 6 Bits | 0x00 | LORD Internal Protocol v0 |
| **Protocol.id** | 4.1 | 2 Bytes | 0x7565 | LORD Internal Protocol |

## 5.4 Device Information

These are standard device information PGNs that are sent from the device to the ECU and may be requested individually from the device by sending the 0xEA00 (59904) command.

| 5.4.1 Software Identification PGN 65242 (0xFEDA) | |
|---|---|
| **Description** | BAM message containing LORD firmware revision number/s. Data is in the form of a single ASCII string with three fields, each field separated by an ASCII “*”. The first byte of the response is the count (3) of fields.<br>This PGN can be requested from the device (use PGN 0xEA00 to request) |
| **Response example** | 0x18 EC FF FC 20 33 00 08 FF DA FE 00 (BAM 8 pkt response header)<br>0x1C EB FF FC 01 03 36 32 34 33 2D 37 (3 fields, first six chars “6243-7”)<br>0x1C EB FF FC 02 37 39 30 23 31 2E 30 (next seven chars “790#1.0”)<br>0x1C EB FF FC 03 2E 31 34 2A 36 32 35 (next seven chars “.14*625”)<br>0x1C EB FF FC 04 38 2D 37 37 36 30 23 (next seven chars “8-7760#”)<br>0x1C EB FF FC 05 31 2E 31 2E 36 38 2A (next seven chars “1.1.68*”)<br>0x1C EB FF FC 06 36 32 35 39 2D 37 37 (next seven chars “6259-77”)<br>0x1C EB FF FC 07 33 30 23 31 2E 30 2E (next seven chars “30#1.0.”)<br>0x1C EB FF FC 08 35 30 FF FF FF FF FF (last seven chars “50”…..) |
| **Byte 1** | Number of string fields to follow. |
| **Value 1** | M Series model number, '#', firmware version |
| **Value 2** | VRU model number, '#', firmware version |
| **Value 3** | IMU model number, '#', firmware version |

| 5.4.2 ECU Identification Information PGN 64965 (0xFDC5) | | |
|---|---|---|
| **Description** | BAM message containing ECU Identification Information. Data is in the form of a single ASCII string with multiple fields, each field separated by an ASCII "*". String fields contain Part #, Serial #, Location, ECU Type, manufacturer Name, and hardware revision. This is identification is for hardware rather than software and all the fields are predefined.<br>This PGN can be requested from the device (use PGN 0xEA00 to request). | |
| **Response example** | 0x18 EC FF FC 20 45 00 0A FF C5 FD 00 (BAM 10 pkt response header)<br>0x1C EB FF FC 01 36 32 34 33 2D 37 37 (first seven chars "6253-77")<br>0x1C EB FF FC 02 39 30 2A 36 32 34 33 (next seven chars "90*6243")<br>0x1C EB FF FC 03 2E 38 33 34 37 32 2A (next seven chars ".83472*")<br>0x1C EB FF FC 04 2A 33 44 4D 2D 4D 56 (next seven chars "*3DM-MV")<br>0x1C EB FF FC 05 35 2D 41 52 2A 4C 4F (next seven chars "5-AR*LO")<br>0x1C EB FF FC 06 52 44 20 53 65 6E 73 (next seven chars "RD Sens")<br>0x1C EB FF FC 07 69 6E 67 20 4D 69 63 (next seven chars "ing Mic")<br>0x1C EB FF FC 08 72 6F 53 74 72 61 69 (next seven chars "roStrai")<br>0x1C EB FF FC 09 6E 2A 32 30 67 2C 31 (next seven chars "n*20g1")<br>0x1C EB FF FC 0A 30 30 30 64 70 73 FF (last seven chars "000dps".) | |
| **J1939 Field Names** | | |
| **String field 1** | Model Number (MV5/ML5) | Part # |
| **String field 2** | Serial Number (MV5/ML5) | Serial # |
| **String field 3** | <empty> | Network Location |
| **String field 4** | Model Name | CU Type |
| **String field 5** | "LORD Sensing MicroStrain" | Manufacturer |
| **String field 6** | Device Options Field | HW Version |

| 5.4.3 Component Identification PGN 65259 (0xFEEB) | |
|---|---|
| **Description** | BAM message containing the model and serial number Information. Data is in the form of a single ASCII string with multiple fields, each field separated by an ASCII "*".<br>This PGN can be requested from the device (use PGN 0xEA00 to request). |
| **Response Example** | 0x18 EC FF FC 20 18 00 04 FF EB FE 00 (BAM 4 pkt response header)<br>0x1C EB FF FC 01 2A 33 44 4D 2D 4D56 (first seven chars "*3DM-MV")<br>0x1C EB FF FC 02 35 2D 41 52 2A 36 32 (next seven chars "5-AR*62")<br>0x1C EB FF FC 03 34 33 2E 38 33 34 37 (next seven chars "43.8347")<br>0x1C EB FF FC 04 32 2A 2A FF FF FF FF (last seven chars "2**"….) |
| **J1939 Field Names** | |
| **String field 1** | <empty> |
| **String field 2** | Model Name |
| **String field 3** | Serial Number |
| **String field 4** | <empty> |

## 5.5 Configuration Commands

These utilize the Proprietarily Configurable Messaging PGNs. They comprise a set of configuration parameters and functional commands not covered by the J1939 spec. We use the Configurability Message PGNs in free form similar to other manufacturers and preferred by customers.

The Set/Get commands are all used in the same manner: The MV5 or ML5 receives the message and immediately applies the new setting and stores it so that the setting is persistent across power cycles. If the parameter value is 0xFFFF (or maximum value or NaN) the CA will apply the default values instead (factory defaults). The sensor will return a standard J1939 acknowledgement message for all the settings commands in this section to indicate that the command was received and whether was successful. The settings may be read back using the "Request Information (0xEA00)" command. These commands may be transmitted to the broadcast ID (0xFF), in which case all units which receive the message will be affected. No acknowledgement is returned in this case. Settings cannot be read out using the broadcast ID because they would be indistinguishable from broadcast commands.

Note that applying a setting utilizes non-volatile memory which has a finite durability of 32,000,000 settings changes. Writing a setting value that is the same as the previous value does not use up a setting change cycle. This should be considered when programming the ECU.

| 5.5.1 Set/Get MV5 J1939 NAME PGN 45312 (0xB100) | | | | |
|---|---|---|---|---|
| **Description** | Sets the various J1939 NAME fields. Arbitrary Address is not supported and must be 0. This PGN can be requested from the device (use PGN 0xEA00 for "get" request). | | | |
| **Example** | 0x18 B1 FC 99 01 02 03 04 00 00 00 00 (set) | | | |
| **SPN** | Bit position (Byte.bit) | Range | Notes | Offset |
| **Industry Group** | 1 | 0..7 | See J1939 standard. | N/A |
| **Vehicle System** | 2 | 0..127 | | N/A |
| **Vehicle System Instance** | 3 | 0..15 | | N/A |
| **Function** | 4 | 0..255 | | N/A |
| **Function Instance** | 5 | 0..31 | | N/A |
| **ECU Instance** | 6 | 0..7 | | N/A |
| **Arbitrary Address Capability** | 7.1 | 0 | Must be 0 | N/A |

| 5.5.2 Set/Get Data Period (Rate) PGN 45568 (0xB200) | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | This command sets the output rate for a given data PGN. The default period is 10 ms. The specified PGN can be disabled by using a transmission period of 0.<br>This PGN can be requested from the device (use PGN 0xEA00 for "get" request). | | | | | |
| **Example** | 0x18 B2 FC 99 29 F0 00 64 00 (set) | | | | | |
| **SPN** | Bit position (Byte.bit) | Length | Resolution | Offset | Range | Default Range |
| **Data PGN** | 1 | 3 Bytes | PGN of transmitted data | | | |
| **Transmission Period** | 4 | 2 Bytes | 1 ms | 0 | 2 to 500. Use 0 to disable. | 10ms (0xFFFF) |

| 5.5.3 Set/Get Filter Bandwidth PGN 45824 (0xB300) | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Sets the low pass filter bandwidth.<br>This PGN can be requested from the device (use PGN 0xEA00 for "get" request). | | | | | |
| **Example** | 0x18 B3 FC 99 2D F0 00 FA 00 (set | | | | | |
| **SPN** | Bit position (Byte.bit) | Length | Resolution | Offset | Range | Default Value |
| **Data PGN** | 1 | 3 Bytes | PGN of transmitted data | | | |
| **Bandwidth** | 4 | 2 Bytes | 1 Hz | 0 | 1 to 250 | 40 Hz (0xFFFF) |

| 5.5.4 RESET ATTITUDE PGN 46080 (0xB400) | |
|---|---|
| **Description** | Restarts the attitude measurement (May be used in the event of over-ranging).<br>There are no data fields for this PGN. |
| **Example** | 0x18 B4 FC 99 FF (set) |

| 5.4.5 Create Sensor to Vehicle Rotation PGN 46336 (0xB500) | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | Tares the sensor and treats the current orientation as the reference. The pitch and roll granularity parameters cause the sensor to round absolute orientation to the nearest multiple of the granularity before applying a tare translation.<br>If the sensor is mounted with a +47° absolute pitch and a tare command is issued with a 5° pitch granularity, the sensor applies a -45° rotation transform on the pitch axis, and the resulting angle reported on the pitch axis is 2°. With a granularity of 0°, an exact-angle tare is performed.<br>The yaw direction is treated as an offset value to the current absolute yaw. This allows sensors mounted in different directions to have yaw axes aligned in the vehicle reference frame. | | | | | |
| **Example** | 0x18 B5 FC 99 00 00 10 0E (set) | | | | | |
| **SPN** | Bit position (Byte.bit) | Length | Resolution | Offset | Range | Default Values |
| **Roll Granularity** | 1 | 1 Bytes | 1° per bit | 0° | 0 to 90° | 0° |
| **Pitch Granularity** | 2 | 1 Bytes | 1° per bit | 0° | 0 to 90° | 0° |
| **Yaw Direction** | 3 | 2 Bytes | 0.1° per bit | 0° | 0° to 360° | 0° |

### 5.5.6 Set/Get Sensor to Vehicle Rotation PGN 46592 (0xB600)

| | | | | | | |
|---|---|---|---|---|---|---|
| **Description** | The output of the device is rotated so that when the sensor is at the reference position (0° on all axes), the actual output corresponds to the rotation angles stored at this index. This can be used to adjust mounting orientation with respect to the vehicle or component orientation. For example, if the sensor is mounted +90° on the Y axis when the vehicle is actually at 0°, set the Y rotation below to -90°. That results in the sensor outputting 0° when the vehicle is at 0° rather than outputting 90°.<br><br>To request this PGN from the device use PGN 0xEA00 for "get" request. | | | | | |
| **Example** | 0x18 B6 FC 99 10 0E 10 0E 10 0E (set) | | | | | |
| **SPN** | Bit position (Byte.bit) | Length | Resolution | Offset | Range | Default |
| **X Rotation** | 1 | 2 Bytes | .1° per bit | -180° | -180° to +180° | 0° |
| **Y Rotation** | 3 | 2 Bytes | .1° per bit | -180° | -180° to +180° | 0° |
| **Z Rotation** | 5 | 2 Bytes | .1° per bit | -180° | -180° to +180° | 0° |

### 5.5.7 LOCK/UNLOCK Configuration Mode PGN 49152 (0xC000)

| | | | |
|---|---|---|---|
| **Description** | Locks B100 to BF00 PGNs. When locked, those messages will be ignored by the device, however, the values of 0xB100, B200, B300, B600, and C000 may still be requested through the request information command (0xEA00). | | |
| **Example** | 0x18 C0 FC 99 50 49 4D 32 4E 41 43 01 (lock)<br>0x18 C0 FC 99 50 49 4D 32 4E 41 43 00 (unlock) | | |
| **SPN** | Bit position (Byte.bit) | Length | Notes |
| **Key Code** | 1 | 7 Bytes | Must be 0x43414E324D4950 |
| **Lock/Unlock** | 8 | 1 Bit | 1 to lock, 0 to unlock |

# 6. Support

## 6.1 Repair and Calibration

### General Instructions

For assistance, please contact LORD Sensing Sales or Technical Support to obtain a Return Merchandise Authorization (RMA) number. Returned merchandise must be in the original packaging, including manuals, accessories, cables, etc. with the RMA number clearly printed on the outside of the package. Removable batteries should be removed and packaged in separate protective wrapping. Please include the LORD Sensing model number and serial number, as well as your name, organization, shipping address, telephone number, and email. Normal turnaround for RMA items is seven days from receipt of item by LORD Sensing.

### Warranty Repairs

LORD Sensing warrants its products to be free from defective material and workmanship for a period of one (1) year from the original date of purchase. LORD Sensing will repair or replace, at its discretion, a defective product if returned to LORD Sensing within the warranty period. This warranty does not extend to any LORD Sensing products that have been subject to misuse, alteration, neglect, accident, incorrect wiring, mis-programming, or use in violation of operating instructions furnished by LORD Sensing. It also does not extend to any units altered or repaired for warranty defect by anyone other than LORD Sensing.

### Non-Warranty Repairs

All non-warranty repairs/replacements include a minimum charge. If the repair/replacement charge exceeds the minimum, LORD Sensing will contact the customer for approval to proceed beyond the minimum with the repair/replacement.

## 6.2 Technical Support

There are many resources for product support found on the LORD Sensing website including technical notes, FAQs, and product manuals.

https://www.microstrain.com/contact-support

https://www.microstrain.com/inertial/mv5-ar

https://www.microstrain.com/inertial/ml5-ar

For further assistance our technical support engineers are available to help with technical and applications questions.

**Technical Support** sensing_support@LORD.com

**Phone:** 802-862-6629

Live Chat is available from the website during business hours: 8:00 AM to 5:00 PM (Eastern Time US & Canada)

## 6.3 Sales Support

For further assistance, our sales team is available to help with product selection, ordering options, and questions.

**Sales Support** sensing_sales@LORD.com

**Phone:** 802-862-6629

8:00 AM to 5:00 PM (Eastern Time US & Canada)

http://www.microstrain.com/inertial

## 6.4 Safety

**WARNING**

**PERSONAL INJURY**

DO NOT USE these products as safety or emergency stop devices or in any other application where failure of the product could result in personal injury.

**Failure to comply with these instructions could result in death or serious injury.**

**WARNING**

**IMPROPER INSTALLATION**

Consult with local safety agencies and their requirements when designing a machine-control link, interface, and all control elements that affect safety.

Strictly adhere to all installation instructions.

**Failure to comply with these instructions could result in death or serious injury.**