POWERFLEET®
People Powered AIoT

Version 1.0

MiX 4000 / MiX 6000

3-Axis Accelerometer Application Note

Table of Contents

1 Overview

The purpose of this document is to provide detailed instructions on how to configure the 3-Axis accelerometer on the MiX 4000 and MiX 6000 product range. The document will provide examples of how to set up the event s as well as how to configure the “Impact Severity Parameter” used by the 3-Axis Accelerometer for impact detection.

The document also contains a section with frequently asked questions about the accelerometer functionality and the output from the events.

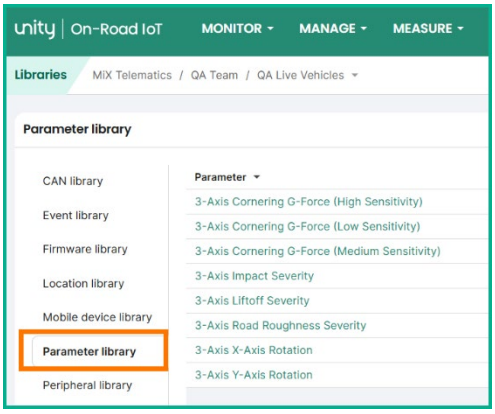
2 General Event Configuration

It must be noted that all the examples listed in the section below are just for illustration purposes and that you will have to find thresholds and values that work for your specific vehicle and application. Since the accelerometer is built into the OBC (on the PC board) the values are affected by where and how the MiX 4000 and MiX 6000 unit is installed.

The following parameters have been defined for the on-board 3-Axis accelerometer:

3-Axis Cornering G-Force (High Sensitivity)
3-Axis Cornering G-Force (Low Sensitivity)
3-Axis Cornering G-Force (Medium Sensitivity)
3-Axis Impact Severity
3-Axis Lift-off Severity
3-Axis Road Roughness Severity
3-Axis X-Axis Rotation
3-Axis Y-Axis Rotation

Note that the three cornering forces will return the same values.



Units and recommended usage:

1. 3-Axis Cornering G-Force (High Sensitivity) occurs in increments of 1G and the value is always positive (i.e. cannot distinguish between left and right cornering). 3G cornering force is recommended.
2. Impact Severity gives values between 0 and 100 with 100 being the most severe impact.
3. Lift-off severity occurs in increments of 10 mili-G, this means a value of 100 = 1G; 200 = 2G
4. Axis Rotation occurs in degrees, 90 degrees means it is on its side and 180 degrees means it is upside down.
5. Road Roughness gives values between 0 and 100 with < 20 on a smooth road and > 45 on a very rough road.

- 3-Axis Impact Severity … 0 (min) to 100 (max)
- 3-Axis Lift-off Severity … increments of 10 mili-G
- 3-Axis Road Roughness Severity… 0 (min) to 100
- (max)
- 3-Axis X-Axis Rotation … 0 degrees to 180
- degrees
- 3-Axis Y-Axis Rotation … 0 degrees to 180
- degrees
- **3-Axis Cornering G-Force (High Sensitivity)**
- ~~3-Axis Cornering G-Force (Low Sensitivity)~~
- ~~3-Axis Cornering G-Force (Medium Sensitivity)~~

Note also that “3-Axis Cornering G-Force (High Sensitivity)”, “3-Axis Cornering G-Force (Low Sensitivity)” and “3-Axis Cornering G-Force (Medium Sensitivity)” will provide the same values, so it is recommended that only “3-Axis Cornering G-Force (High Sensitivity)” is used

3 Auto Calibration of 3-Axis Accelerometer

For more detail about the auto calibration process, refer to the Application Note:

- "3Axis Accelerometer Orientation - Application Note.pdf"

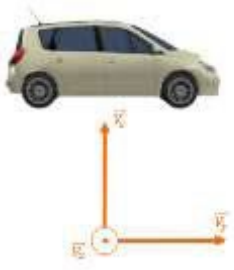
For the purpose of this document is sufficient to understand that the X and Y planes are automatically calibrated using the speed input, regardless of how the OBC is installed (sideways, flat or even upside down).

The auto calibration has the following benefits:

1) It uses the 3-Axis accelerometer and any speed input to calibrate the orientation of the unit.
2) Any speed input is valid (not just GPS) e.g. Speed sender, CAN or GPS.
3) It can determine if orientation of the device has changed and will automatically recalibrate (e.g. after re-installation or when the unit is moved to another location).
4) It provides more accurate cornering forces and can detect acceleration and deceleration via the accelerometer.

Independent of the actual orientation and position of the unit, the 3-Axis will be calibrated as in the picture on the right.

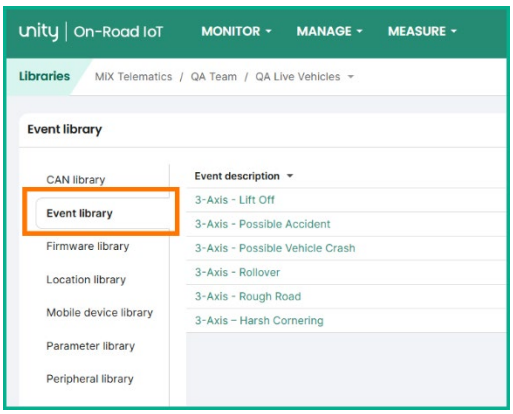
- Z - Up or down (gravity vector)
- Y – to the front of the vehicle



4 Example Definitions 3-Axis Events

This section will show examples of how to use the parameters above to set up events. The recommended default values are:

3-Axis – Harsh Cornering
3-Axis – Lift Off
3-Axis – Possible Accident (In Trip)
3-Axis – Possible Accident (Out of Trip)
3-Axis – Possible Bumper Bash
3-Axis – Road Roughness = Off Road
3-Axis – Road Roughness = Smooth
3-Axis – Road Roughness = Rough
3-Axis – Rollover



3-Axis – Harsh Cornering	**Event Condition:** In trip (drive) = TRUE **AND** 3-Axis Cornering G-Force (High Sensitivity) > 0.2G **Return Parameter:** 3-Axis Cornering G-Force (High Sensitivity)
3-Axis – Lift Of	**Event Condition:** In trip (drive) = TRUE **AND** 3-Axis Lift-off Severity > 10% **Return Parameter:** 3-Axis Cornering G-Force (High Sensitivity)
3-Axis – Possible Accident (In Trip)	**Event Condition:** In trip (drive) = TRUE **AND** 3-Axis Impact Severity > 25 **Return Parameter:** 3-Axis Impact Severity
3-Axis – Possible Bumper Bash	**Event Condition:** In trip (drive) = TRUE **AND** 3-Axis Impact Severity > 10 **Return Parameter:** 3-Axis Impact Severity
3-Axis – Road Roughness = Smooth	**Event Condition:** In trip (drive) = TRUE AND 3-Axis Road Roughness Severity > 5 **AND** 3-Axis Road Roughness Severity < 20 **Return Parameter:** 3-Axis Road Roughness Severity
3-Axis – Road Roughness = Rough	**Event Condition:** In trip (drive) = TRUE **AND** 3-Axis Road Roughness Severity > 20 AND 3-Axis Road Roughness Severity < 35 **Return Parameter:** 3-Axis Road Roughness Severity
3-Axis – Road Roughness = Off Road	**Event Condition:** In trip (drive) = TRUE **AND** 3-Axis Road Roughness Severity > 35 **Return Parameter:** 3-Axis Road Roughness Severity
3-Axis – Rollover	**Event Condition:** In trip (drive) = TRUE **AND** (3-Axis X-Axis Rotation > 45 **OR** 3-Axis Y-Axis Rotation > 45) **Return Parameter:** 3-Axis X-Axis Rotation

5 Sensitivity Settings in On Road IoT

There are additional sensitivity settings in On Road IoT for the 3-Axis parameters. These settings are found in the Mobile Device template of the MiX 4000 and MiX 6000.

Changing any of these parameters will have an impact on the sensitivity of the 3-Axis accelerometer and might result in different optimum values than those recommended above.

Access these as follows: Manage • Templates • Mobile device template	
Scroll down until you see the “Three Axis Accelerometer” section: 1. All default values are 50. 2. A value of zero (0) means the feature is disabled. 3. Lift-off (and Cornering) Sensitivity is also used for Pitch and Roll. 4. Pitch and Roll Detection Sensitivity is not used by Firmware. 5. Road Roughness is scaled and filtered from 1 second (100%) to 100 seconds (1%). A value of 50 means it is filtered over 50 seconds. 6. Lift-off and (Pitch and Roll) Sensitivity is scaled and sampled from 10 ms (100%) to 1 second (1%). A value of 50 means it is sampled over 50 ms (0.5 seconds) 7. Impact Detection Sensitivity is scaled from 0.5G (100%) to 3.5G (1%). The default of 50 therefore means the threshold is set at 2G (50%)	

It is possible to combine some of the parameters and adjust these thresholds in order to define new events. For example, if you want to measure the degree of “Customer Comfort” on a bus, you can for example define an event as follows:

Define: Speed = A (in km/h)

Define: Road Roughness Severity = **B** (RMS energy filter window in seconds)

Define: 3-Axis Cornering = **C** (in G force)

THEN: If (Speed > **A** km/h) AND (Road Roughness > **B** OR 3-Axis Cornering G-Force > **C**)

A ROUGH RIDE will then be classified as triggered if the passengers experience forward movement (braking),

backward movement (acceleration), sideways movement (cornering) or up-down movement (pot-holes or speed-bumps) when you use values of:

A = 20 km/h

B = 15

C = 0.2 G

6 Impact Severity

The ***Impact Severity Parameter*** measures the amount of energy observed in a specific timeframe, and returns a value between 0 and 100. The major differences between the other/older algorithms and the current implementation are:

- G-Force due to gravity is effectively removed from the calculation.
- Acceleration history is stored as a buffer of 3D vectors, instead of being stored as a magnitude average .
- Acceleration data is integrated over time to calculate the impact energy, which eliminates ringing as a cause of false triggers.

7 Conversions

To convert between configurations for the old crash detection module (impact sensors) and the new algorithm, the following calculation can be used:

Define **A** = acceleration in g

Define **B** = time in milliseconds

THEN

Using the specification of an average A g acceleration over B milliseconds

- A (acceleration in g) is capped at 8g, so for example for 11g over 25ms, only 8g will be considered.
- B (timeframe in milliseconds) is capped at 300ms (which is generally larger than most specifications), so for example 11g over 350ms, only 8g over 300ms will be considered.

The severity value specified in the configuration then translates to:

Impact Severity = (A * B) / 10

Examples

1. Average 11g over 25ms: 11g capped to 8g, so Severity = (8 * 25) / 10 = 20

2. Average 5g over 50ms: Severity = (5 * 50) / 10 = 25

3. Average 1g over 350ms: 300ms is capped at 300ms, so Severity = (1*300)/10 = 30

8 Recommendations

Powerfleet recommends that the G-force impact sensor algorithms are set at detecting crash pulses which equal or exceed a 5g average over 50ms, or a 3g average over 100ms.

Relying on the data and recommendations, it is advisable to set the minimum severity value that would indicate a slight injury to 20.

9 Frequently asked questions

Must the OBC be installed in a specific orientation for the accelerometer to work?

For example, like with the old impact sensors X, Y axis?

No, it is not important. The OBC can be installed in any orientation and direction and the 3-Axis accelerometer will do an auto-calibration using GPS data to figure out which direction is forward/backward/sideways and up and down.

At what point does the auto-calibration occur?

Let's say a unit was installed in a certain orientation, and then at some point the orientation was changed, does the auto-calibration occur after an OBC Unit Reset?

The calibration occurs constantly. When the unit powers up, we assume that the unit is lying still in the horizontal plane, and uses the values on the 3 axis as the unit's orientation. This assumption is then fine-tuned by adjusting each axis (if necessary) by 1 mili-G every second.

Why is “Impact Severity” and “Road Roughness” not specified in G?

Severity is a measurement of the amount of energy observed in a specific timeframe and specified as a value between 0 and 100. The value is not expressed in G. Road Roughness is the RMS value over a specific time frame (currently 50 seconds) in 0.1 G resolution i.e. Road Roughness of 30 indicates 300 mG.

Why is there no direction (left/right) for Harsh Cornering?

Why can we set up Harsh Cornering Left and Right when using GPS, but for accelerometer there is only harsh cornering (without direction)?

The current accelerometer algorithm cannot distinguish between cornering forces in the XY-plane, this will be an enhancement in future versions of the firmware. If direction of the corner is required, then the GPS must be used as source of the cornering force.

Will Harsh Cornering with different sensitivity levels be available at some point?

A single setting can adjust the sensitivity of Lift-off, Tilt, and acceleration in the horizontal plane (i.e. acceleration, braking and cornering combined). This setting is not adjustable. Currently the setting is fixed to smooth the accelerometer data over a 500ms window before using the filtered data for analysis. (In the previous concept for FM3316 Impact sensor, the only difference between High, Medium, Low was a hardcoded filter of 1, 2, 3 seconds smoothing). On Road IoT will allow any value to be configured, which means there are nohardcoded High, Medium and Low values, but rather a value and filter duration.

Is it possible to store the 3-axis values on a second-per-second basis as TACHO data?

This feature depends on configuration changes and will only be available in a future release of On Road IoT.