

# Impact and Rollover Detection

User Manual

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# 1 Introduction

## 1.1 About the Functionality

When the impact detection feature is active, the FM device monitors its acceleration in all directions and generates records every time when the acceleration exceeds the configured limits. You can use impact detection to receive notifications to the server about irresponsible drivers, who hit sidewalks or other obstacles, or when the driver gets into an accident. This feature can also be used for rollover detection in environments, where vehicle rollover is possible.

## 1.2 Legal Information

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## 1.3 Compatibility

This functionality is compatible with the following devices with the newest firmware version:

- FM-Tco4 HCV
- FM-Tco4 LCV
- FM-Pro4
- FM-Eco4 (Configurable threshold only)
- FM-Eco4 S
- FM-Plug4 (Configurable threshold only)

## 1.4 Contact Information

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## 1.5 Document Changelog

| Version    | Date       | Modification  |
|------------|------------|---|
| <b>1.0</b> | 2016-09-07 | Initial draft.  |
| <b>1.1</b> | 2016-09-23 | Added: Shock detection for FM-Eco4 devices.   |
| <b>1.2</b> | 2016-10-06 | Added: Rollover detection feature description.  |
| <b>1.3</b> | 2016-10-24 | Added: Shock detection operation in sleep mode and in deep sleep mode.  |
| <b>1.4</b> | 2016-11-18 | Added: Rollover detection for FM-Eco4 devices.<br>Updated: Recommendations for shock detection IO parameters.                                       |
| <b>1.5</b> | 2018-08-29 | Added: Description of optional impact calculation on the Z axis.<br>Updated: Compatible device list.<br>Updated: Rollover detection default values. |
| <b>1.6</b> | 2018-10-08 | Updated: Calibration description.   |
| <b>1.7</b> | 2018-11-08 | Added: Shock detection and rollover detection for FM-Plug4 devices.   |
| <b>1.8</b> | 2019-08-30 | Updated: IO parameter names.  |
| <b>2.0</b> | 2019-09-16 | Added: Description of dynamic threshold.<br>Updated: Document structure and design.   |

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## 2 Impact Detection

| FM-Tco4 HCV | FM-Tco4 LCV | FM-Pro4 | FM-Eco4 | FM-Eco4 S | FM-Plug4 |
|-------------|-------------|---------|---------|-----------|----------|
| ✓           | ✓           | ✓       | ✓       | ✓         | ✓        |

### 2.1 Definitions

Discrimination threshold – all acceleration values below this limit will be ignored

Peak limit – a minimum acceleration value that needs to be reached in order to register a shock event

Duration limit – a minimum shock duration required for it to be registered as a shock event

False positive event – a detected shock event that is not an impact

$a_x$  – the acceleration along the x-axis

$a_y$  – the acceleration along the y-axis

$a_z$  – the acceleration along the z-axis

### 2.2 Operation Principles

The device has a built-in accelerometer, that detects if the device is affected by external forces. The detection depends on where/how the device is installed. The accelerometer can be calibrated to align its axes with the axes of the vehicle's coordinate system (see chapter 5 "Accelerometer Calibration").

For the impact detection functionality, only the horizontal components ( $a_x$ ;  $a_y$ ) are taken into calculations. The vertical component ( $a_z$ ) is optional and can be included during configuration if a configurable threshold is used. The magnitude of the resultant acceleration vector can be calculated as follows:

$$\|\mathbf{a}\| = \sqrt{a_x^2 + a_y^2 + a_z^2}$$

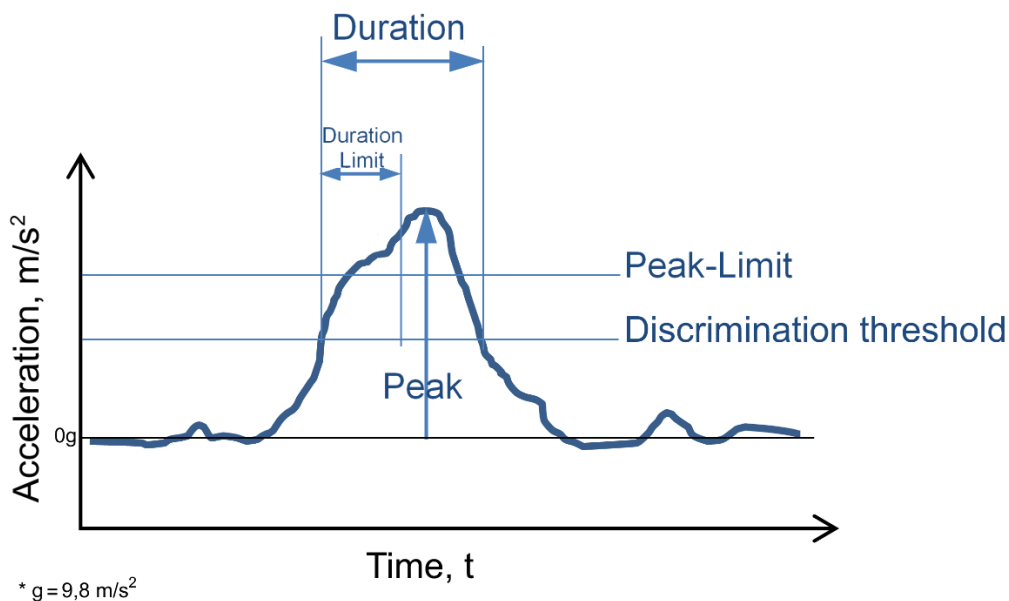
The boundary conditions for the resultant vector are defined by the discrimination threshold and the peak-limit. When the resultant vector crosses the discrimination threshold, a shock event can be generated. The resultant vector is then decomposed into its constituent accelerations and the shock data records contain values of the three acceleration components:  $a_x$ ;  $a_y$ ;  $a_z$ .



Only acceleration experienced from the shock itself is included in the results. The permanent component due to Earth's gravity, present in the z axis direction, is subtracted from the results. Therefore, in a default state, the acceleration measured by the device will be 0 m/s<sup>2</sup> in all directions.

## 2.3 Shock Evaluation Procedure

1. Only shock events with an acceleration amplitude that exceeds the configurable discrimination threshold are processed.
2. The shock duration is measured at the discrimination threshold level.
3. The shock acceleration amplitude is measured at the peak acceleration value.
4. If the amplitude is higher than the configurable peak-limit and the duration is longer than the configurable duration limit, the shock is included in data records.



## 2.4 False Positive Events

In some cases, false positive events may be generated when small shocks are detected. False positive events may be caused by:

- Potholes in the road
- Speed bumps
- Inappropriate installation, when the device is not securely attached or is near moving parts

## 2.5 Dynamic Threshold

| FM-Tco4 HCV | FM-Tco4 LCV | FM-Pro4 | FM-Eco4 | FM-Eco4 S | FM-Plug4 |
|-------------|-------------|---------|---------|-----------|----------|
| ✓           | ✓           | ✓       | ⊘       | ✓         | ⊘        |

In order to reduce the amount of false positive events, the peak limit needs to be adjusted. However, it is not practical to send different configurations each time the vehicle enters a different environment. A dynamic threshold can be used instead.

The dynamic threshold automatically adjusts the discrimination threshold, or in other words, lowers the shock sensitivity at higher speeds. This way, small shocks are ignored when for example, the vehicle is travelling on a highway.



The device must be properly installed for the dynamic threshold to be effective.



We recommend using the dynamic threshold in most cases.

# 3 Rollover Detection

| FM-Tco4 HCV | FM-Tco4 LCV | FM-Pro4 | FM-Eco4 | FM-Eco4 S | FM-Plug4 |
|-------------|-------------|---------|---------|-----------|----------|
| ✓           | ✓           | ✓       | ✓       | ✓         | ✓        |

## 3.1 Definitions

$\Theta$  (theta) – the angle between x-axis and the horizon

$\Psi$  (psi) – the angle between y-axis and the horizon

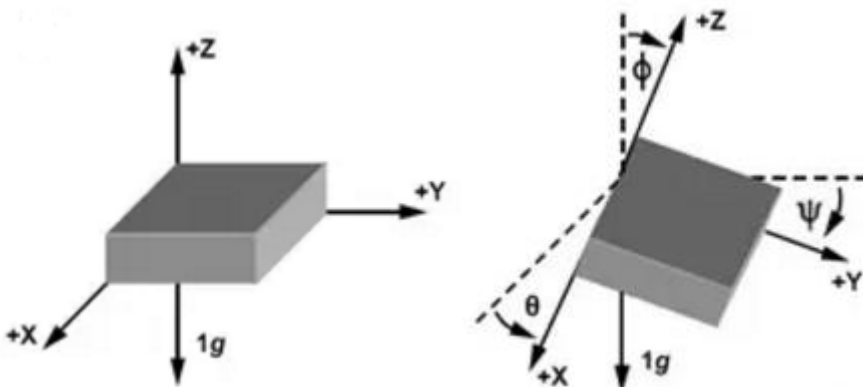
$\Phi$  (phi) – the angle between the gravity vector and the z-axis

$a_x$  – the acceleration along the x-axis

$a_y$  – the acceleration along the y-axis

$a_z$  – the acceleration along the z-axis

The acceleration along each axis is expressed via the gravitational (free-fall) acceleration constant  $g = 9.8 \text{ m/s}^2$



## 3.2 Operation Principles

If this functionality is enabled, the FM device constantly monitors the vehicle's angles in relation to the horizontal plane. The horizontal plane orientation in relation to the FM device is determined during accelerometer calibration.

A rollover event will be registered, if these conditions are satisfied:

- The vehicle's tilt angle in any axis is bigger than the predefined value
- It remains in that position for a longer time period than the predefined duration



# 4 Configuration

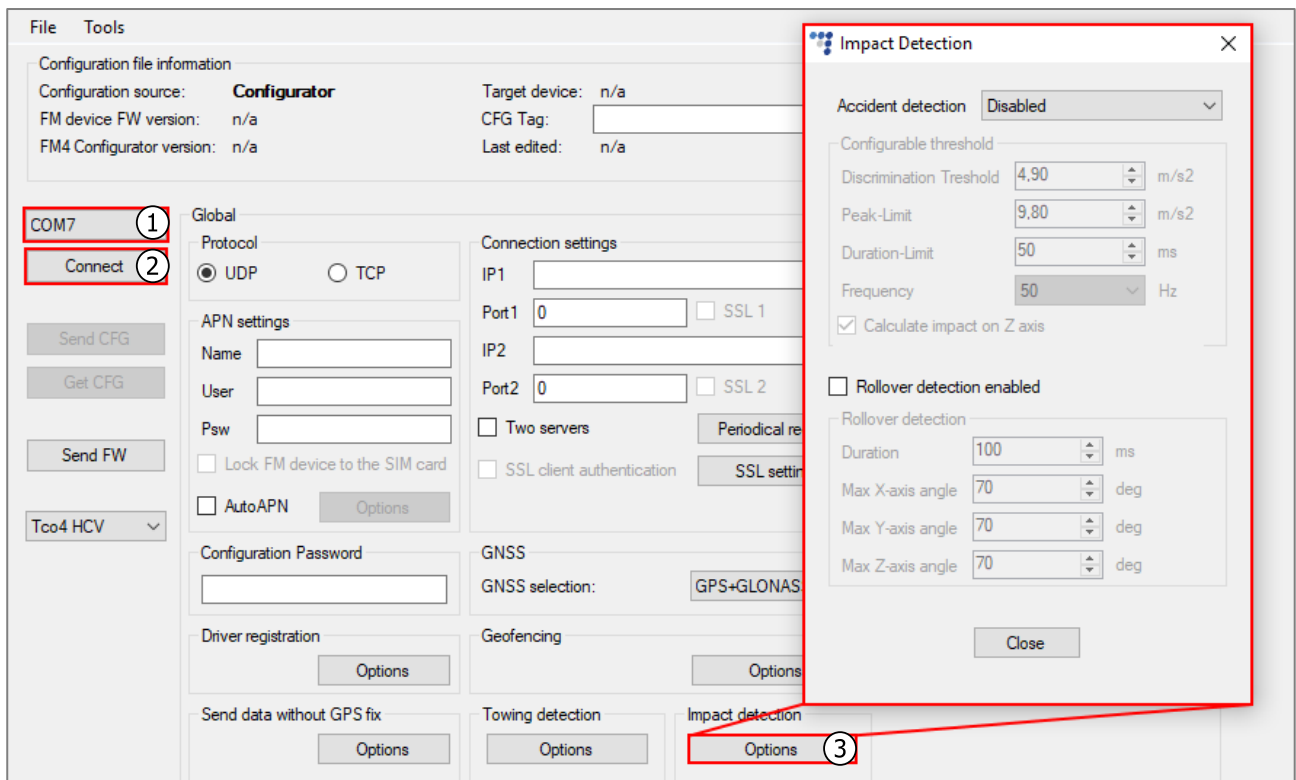


This functionality requires the use of the advanced configurator.

## 4.1 Starting the Configuration

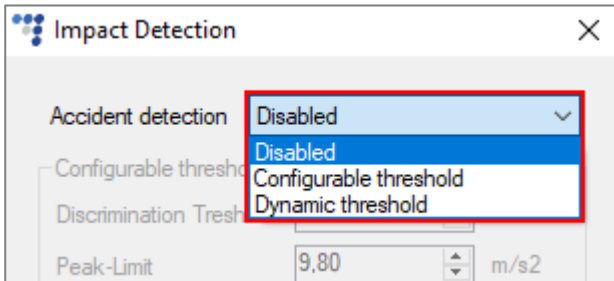
To start the configuration, follow these steps:

1. Open the advanced configurator. Select the COM port to which your device is connected.
2. Click **Connect**.
3. Click the **Options** button in the **Impact detection** section to open the **Impact Detection** window.



## 4.2 Impact Detection Configuration

To start, select which threshold you wish to use: configurable or dynamic. The functionality is disabled by default.

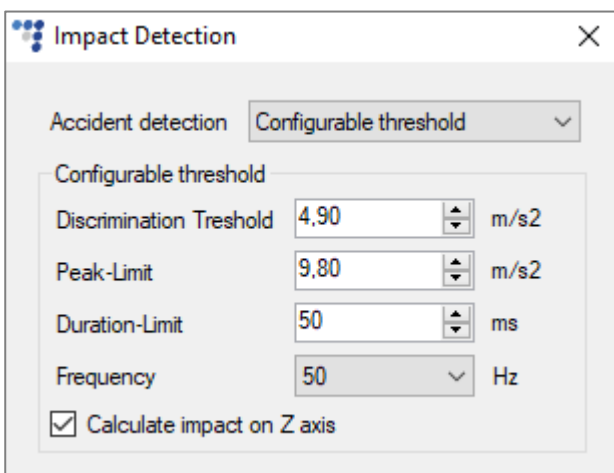


If shock detection is enabled, the device will not enter sleep/deep sleep mode.

### 4.2.1 Configurable Threshold Configuration

Set the discrimination threshold and configure other relevant parameters.

|                                   |   |
|-----------------------------------|---|
| <b>Discrimination Threshold</b>   | At what amplitude shock measurements start.<br>Default value: 4.9 m/s <sup>2</sup> (0.5 g)  |
| <b>Peak-Limit</b>                 | The minimum amplitude needed for a shock event to be registered.<br>Default value: 9.8 m/s <sup>2</sup> (1 g)                     |
| <b>Duration-Limit</b>             | For how long the amplitude must be above the discrimination threshold for a shock event to be registered.<br>Default value: 50 ms |
| <b>Frequency</b>                  | How often the device checks whether a shock event has occurred.<br>Default value: 50 Hz   |
| <b>Calculate impact on Z axis</b> | If ticked, the Z-axis will be included in impact detection measurements.<br>Default value: Enabled                                |



## 4.2.2 Dynamic Threshold Configuration

Configure the parameters required for the dynamic threshold.

|                                       |  |
|---------------------------------------|--|
| <b>Speed condition enabled</b>        | If ticked, an additional speed condition will be used that checks if the vehicle has stopped.<br>Default value: Disabled |
| <b>Duration until condition check</b> | If the vehicle stops during this time period after an impact, a record is generated.<br>Default value: 5000 ms           |



If the speed condition is enabled, a record will be generated even if the vehicle stops normally during the configured time period.

Impact Detection

Accident detection: Dynamic threshold

Dynamic threshold

Speed condition enabled

Duration until condition check: 5000 ms

## 4.3 Rollover Detection Configuration

Enable rollover detection and configure other relevant parameters.

|                                   |   |
|-----------------------------------|---|
| <b>Rollover detection enabled</b> | If ticked, rollover detection will be enabled.<br>Default value: Disabled.  |
| <b>Duration</b>                   | For how long the tilt must be detected for rollover to be detected.<br>Default value: 100 ms  |
| <b>Max X-axis angle</b>           | The maximum allowed X-axis tilt. If the tilt angle is greater than the entered value, a rollover event is detected.<br>Default value: 70° |
| <b>Max Y-axis angle</b>           | The maximum allowed Y-axis tilt. If the tilt angle is greater than the entered value, a rollover event is detected.<br>Default value: 70° |
| <b>Max Z-axis angle</b>           | The maximum allowed Z-axis tilt. If the tilt angle is greater than the entered value, a rollover event is detected.<br>Default value: 70° |

Impact Detection

Accident detection: Configurable threshold

Configurable threshold

Discrimination Treshold: 4.90 m/s<sup>2</sup>

Peak-Limit: 9.80 m/s<sup>2</sup>

Duration-Limit: 50 ms

Frequency: 50 Hz

Calculate impact on Z axis

Rollover detection enabled

Rollover detection

Duration: 100 ms

Max X-axis angle: 70 deg

Max Y-axis angle: 70 deg

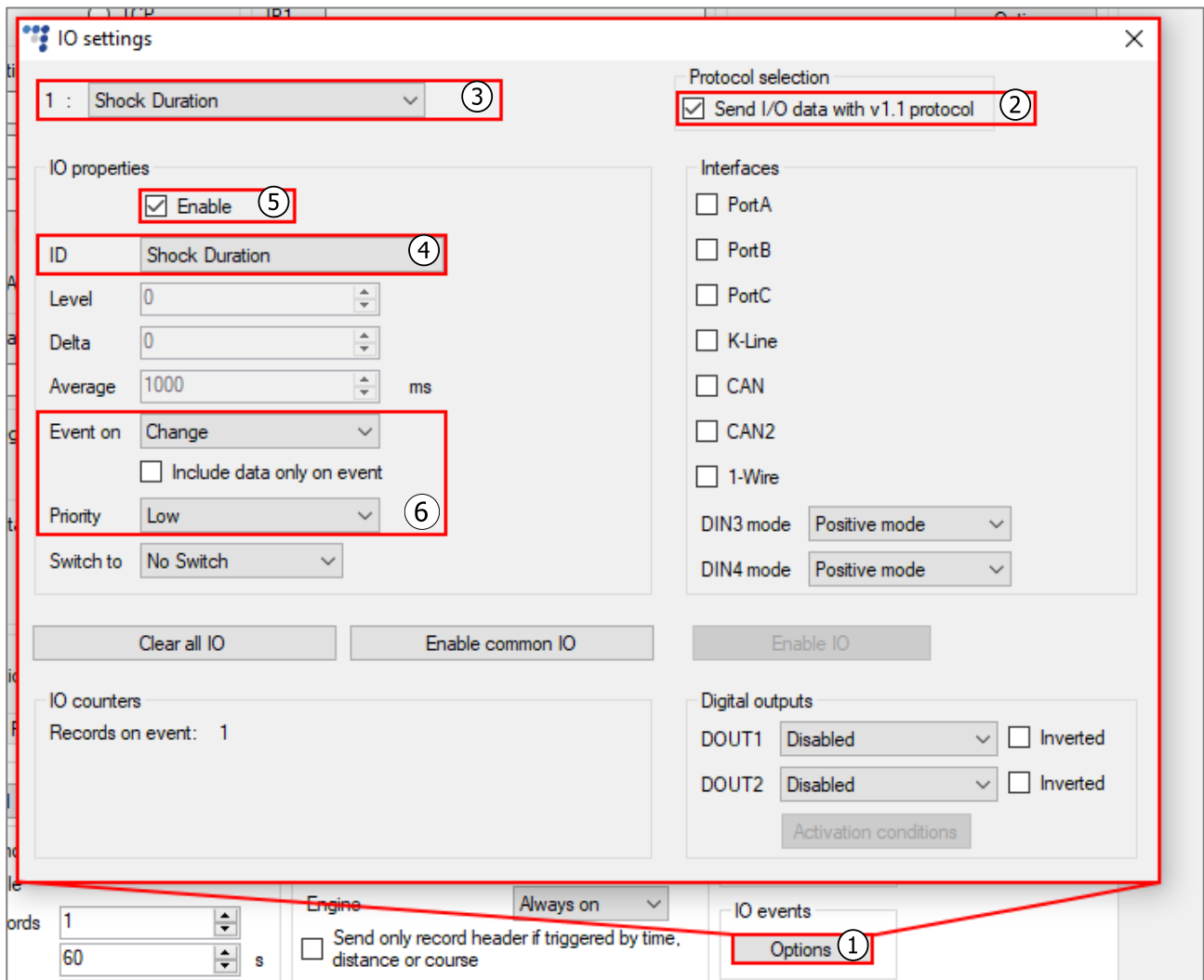
Max Z-axis angle: 70 deg

Close

## 4.4 Enabling IO Parameters

In order to send detailed event data, you need to enable several IO parameters:

1. Click **Options** in the **IO events** section to open the **IO Settings** window.
2. Tick the **Send I/O data with v1.1 protocol** checkbox.
3. Select a parameter slot.
4. Select a parameter that you wish to enable.
5. Tick the **Enable** checkbox.
6. Set **Event on** and **Priority** as desired (a *High* priority will send notifications about shock/rollover events as soon as they occur).
7. Repeat steps 3-6 for other parameters.



In order to send detailed data about shock events, enable the following IO parameters:

- Shock Duration (**Event on** must be set to *Change*)
- G Peak X
- G Peak Y
- G Peak Z

In order to send detailed data about rollover events, enable the following IO parameters:

- Roll over detection
- Angle X-axis
- Angle Y-axis
- Angle Z-axis

## 4.5 Finishing the Configuration

To finish the configuration, close the **Impact Detection** and **IO Settings** windows. Click **Send CFG** to send the configuration to the device.

The screenshot displays the Ruptela Configurator software interface. At the top, there is a 'File' and 'Tools' menu. Below the menu, a 'Configuration file information' section shows details like 'Configuration source: Configurator', 'Target device: n/a', 'FM device FW version: n/a', 'CFM Tag: [input field]', 'FM4 Configurator version: n/a', and 'Last edited: n/a'. The Ruptela logo is visible in the top right corner. The main configuration area is divided into several sections: 'Global' (Protocol: UDP selected), 'Connection settings' (IP1, Port1, IP2, Port2, SSL options), 'Authorized numbers', 'Eco-Drive' (checked), 'Authorized IDs' (checked), 'Audio settings', 'Configuration Password', 'GNSS' (GPS+GLONASS selected), 'Driver registration', 'Geofencing', and 'Movement sensor sensitivity' (slider set to 8). On the left side, there is a vertical toolbar with buttons for 'Disconnect', 'Send CFG' (highlighted with a red box), 'Get CFG', 'Send FW', and 'Too4 LCV'.

## 5 Accelerometer Calibration

The FM device uses a built-in accelerometer to detect shock and rollover events. The detection is largely based on the accelerometer's measurements.

To ensure proper operation, the accelerometer must be calibrated. The accelerometer is calibrated automatically when driving. The accelerometer also recalibrates itself if detects positioning changes when the engine is turned on. Calibration takes up to an hour of driving in an urban location.

If needed, the existing calibration can be reset using the *accreset* SMS command. You may use the *accreset r* SMS command to receive calibration process status updates.



Recalibrate the accelerometer after installation using SMS commands to ensure accurate measurements.

A detailed accelerometer calibration process description is available in the [Eco-Drive configuration manual](#).