Ruptela
Transport Telematics

Impact and Rollover Detection

User Manual

v2.2

2020-04-20

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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:

- Trace5
- FM-Tco4 HCV
- FM-Tco4 LCV
- FM-Pro4
- FM-Eco4 (Configurable threshold only)
- FM-Eco4 S
- FM-Eco4 T
- FM-Plug4 (Configurable threshold only)

1.4 Contact Information

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1.5 Document Changelog

Version	Date	Modification
1.0	2016-09-07	Initial draft.
1.1	2016-09-23	Added: Shock detection for FM-Eco4 devices.
1.2	2016-10-06	Added: Rollover detection feature description.
1.3	2016-10-24	Added: Shock detection operation in sleep mode and in deep sleep mode.
1.4	2016-11-18	Added: Rollover detection for FM-Eco4 devices. Updated: Recommendations for shock detection IO parameters.
1.5	2018-08-29	Added: Description of optional impact calculation on the Z axis. Updated: Compatible device list. Updated: Rollover detection default values.
1.6	2018-10-08	Updated: Calibration description.
1.7	2018-11-08	Added: Shock detection and rollover detection for FM-Plug4 devices.
1.8	2019-08-30	Updated: IO parameter names.
2.0	2019-09-16	Added: Description of dynamic threshold. Updated: Document structure and design.
2.1	2020-04-03	Updated: Dynamic threshold configuration.
2.2	2020-04-20	Removed: Note regarding device sleep with impact detection enabled

1.6 Notations

The following notations are used in this document to highlight important information:

Bold text

Used to indicate user interface elements or for emphasis.

Italic text

Used to indicate items that belong to a list and can be selected, as well as command syntax.

Note

Used to highlight important information or special conditions.

Tip

Suggestions on how to proceed.

Availability table

Trace5	Tco4 HCV	Tco4 LCV	Pro4	Eco4	Eco4 S/T	Plug4
⊘	✓	✓	✓	⊘	⊘	⊘

Used to mark which devices support a given functionality. Device names are written without the FM prefix.

2 Impact Detection

Trace5	Tco4 HCV	Tco4 LCV	Pro4	Eco4	Eco4 S/T	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 ($\boldsymbol{a}_x$; $\boldsymbol{a}_y$) are taken into calculations. The vertical component ($\boldsymbol{a}_z$) 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:

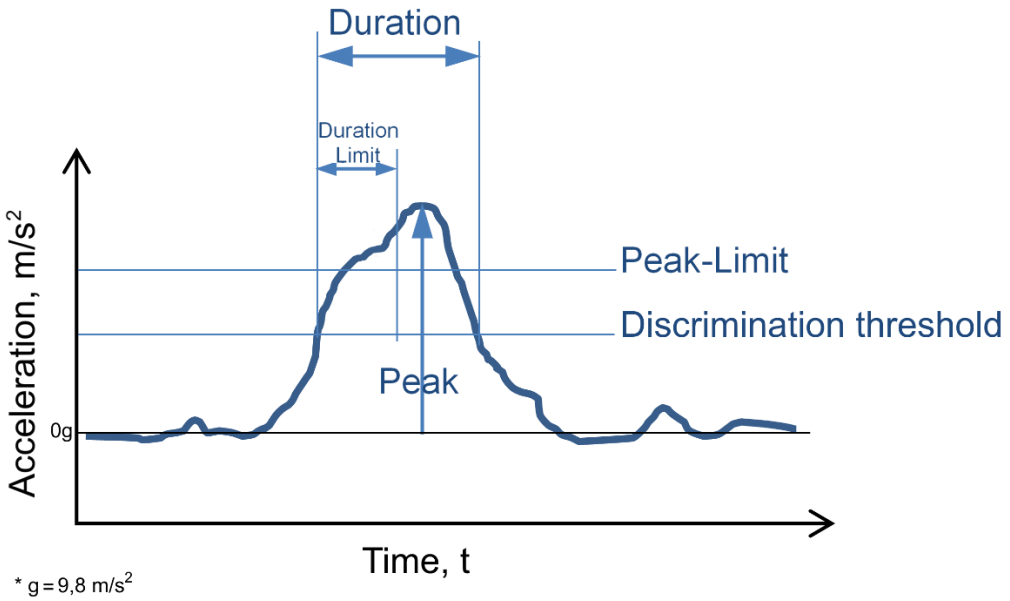
$$\|\boldsymbol{a}\| = \sqrt{\boldsymbol{a}_x^2 + \boldsymbol{a}_y^2 + \boldsymbol{a}_z^2}$$

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: $\boldsymbol{a}_x$; $\boldsymbol{a}_y$; $\boldsymbol{a}_z$.

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^2 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

Trace5	Tco4 HCV	Tco4 LCV	Pro4	Eco4	Eco4 S/T	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, significantly decreasing the chance of registering a false positive crash notification. However, some false positive notifications are still possible from time to time, e.g. due to door slams or driving over potholes.

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

Trace5	Tco4 HCV	Tco4 LCV	Pro4	Eco4	Eco4 S/T	Plug4
✔	✔	✔	✔	✔	✔	✔

3.1 Definitions

Θ (theta) – the angle between x-axis and the horizon

Ψ (psi) – the angle between y-axis and the horizon

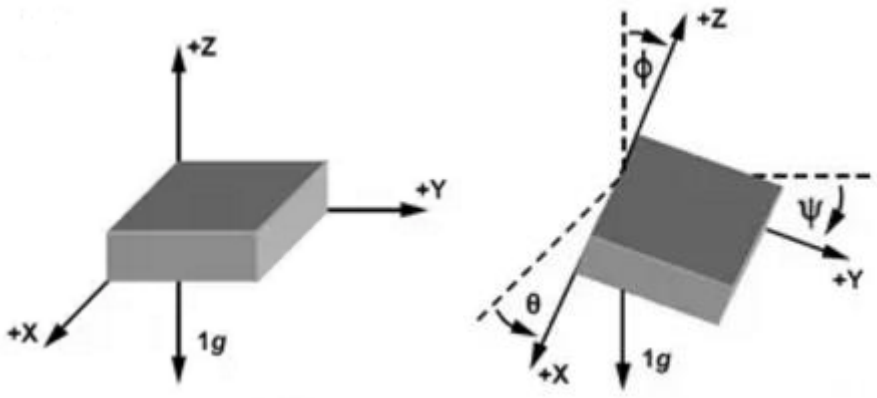
Φ (phi) – the angle between the gravity vector and the z-axis

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 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

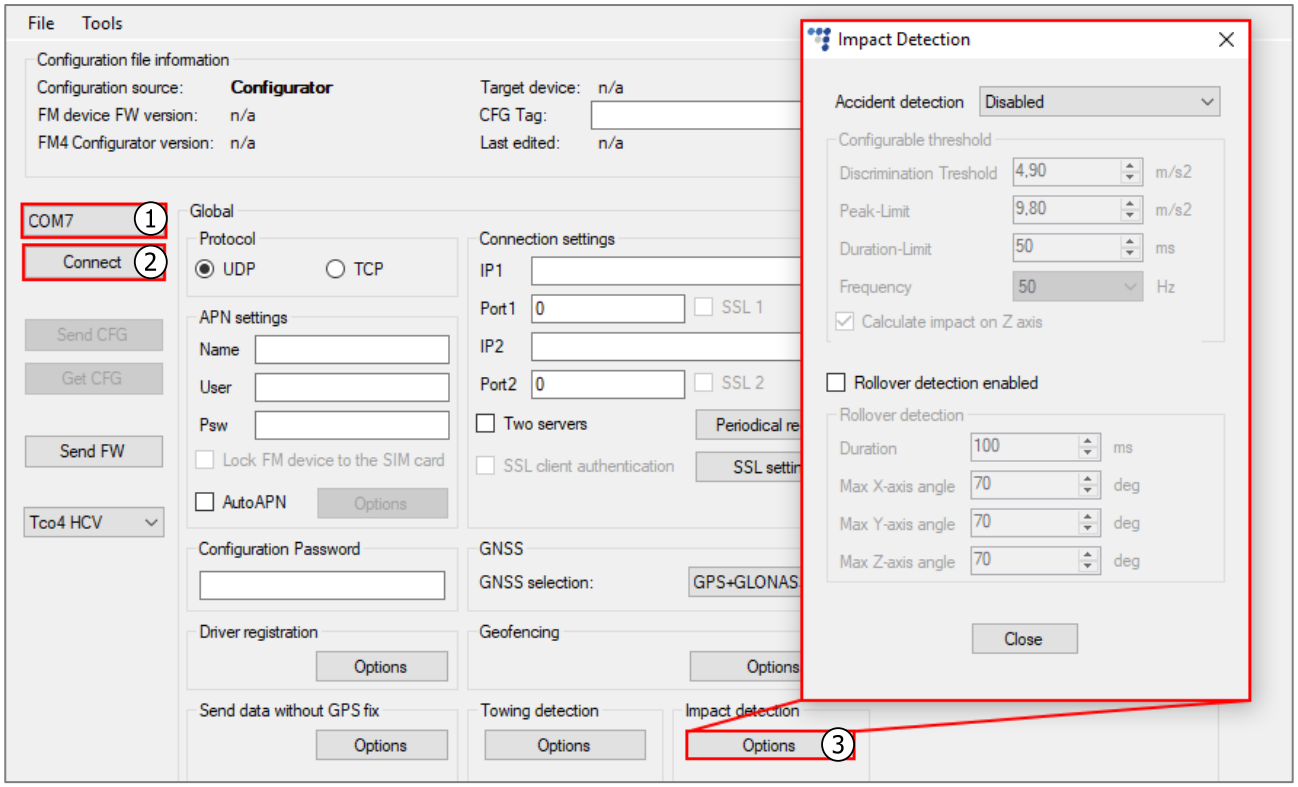
4 Configuration

This functionality requires the use of the advanced configurator.

4.1 Starting the Configuration

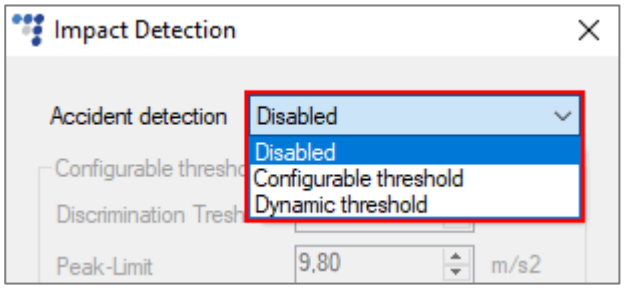
To start the configuration, follow these steps:

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

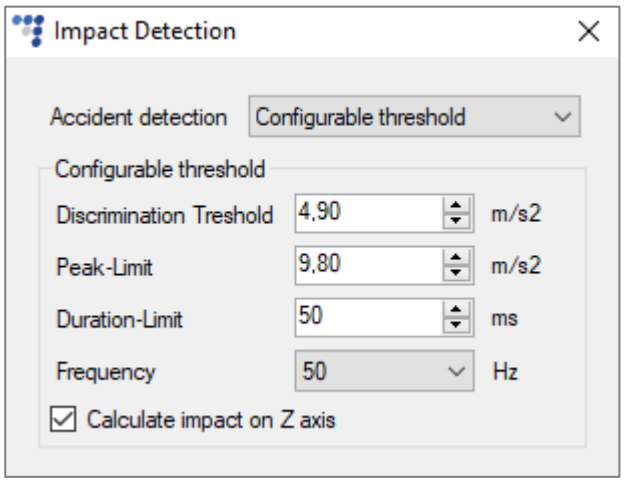
To start, select which threshold you wish to use: configurable or dynamic. The functionality is disabled by default.



4.2.1 Configurable Threshold Configuration

Set the discrimination threshold and configure other relevant parameters.

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



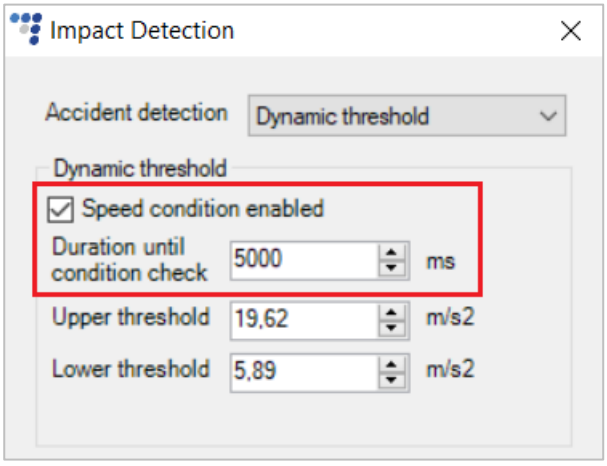
4.2.2 Dynamic Threshold Configuration

Configure the parameters required for the dynamic threshold.

Speed condition enabled	If ticked, an additional speed condition will be used that checks if the vehicle has stopped after the impact is registered by accelerometer. Default value: Disabled
Duration until condition check	If the vehicle stops during this time period after an impact, a record is generated. Default value: 5000 ms
Upper threshold	The highest value the peak limit can obtain. Default value: 19.62 m/s^2
Lower threshold	The lowest value the peak limit can obtain. Default value: 5.89 m/s^2

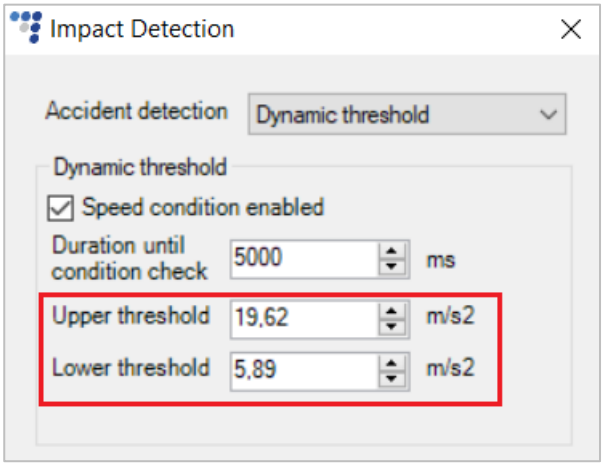
If the speed condition is enabled, a record will be generated even if the vehicle stops normally during the configured time period.

The speed condition provides an option to filter shock events, if the vehicle is constantly exposed to bad road conditions and increasing the thresholds is not an option.



It is not recommended to use the speed condition with heavy vehicles, as it might take a long time for a heavy vehicle to stop even after a real impact due to its high inertia (mass).

The peak limit increases from the value of the lower threshold to the value of the upper threshold as the speed increases. Default threshold values were obtained empirically from light vehicle crash tests, but in general, are suitable for all types of vehicles.



We advise you to increase the thresholds under bad road conditions:

Upper threshold → 27.5 m/s^2

Lower threshold → 7.8 m/s^2.

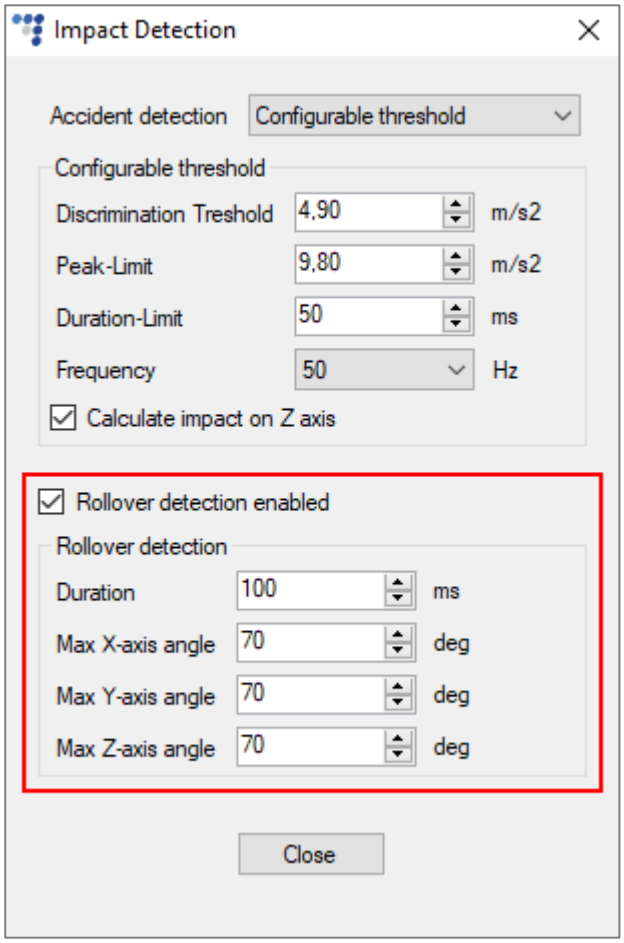
We do not recommend to exceed these values, as it may filter out real impact notifications.

Excessive impacts notifications might indicate poor mounting conditions or unsuitable mounting place.

4.3 Rollover Detection Configuration

Enable rollover detection and configure other relevant parameters.

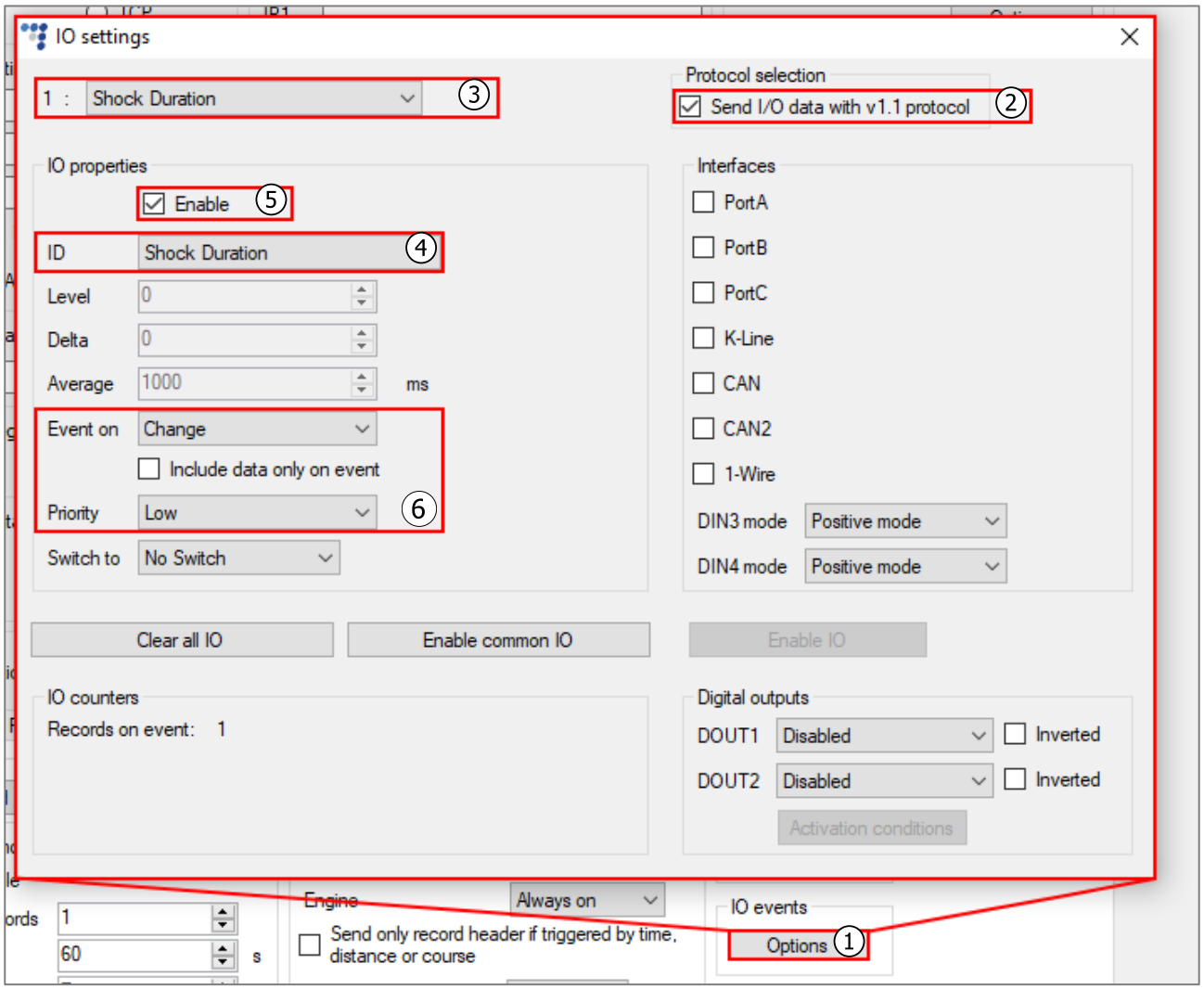
Rollover detection enabled	If ticked, rollover detection will be enabled. Default value: Disabled.
Duration	For how long the tilt must be detected for rollover to be detected. Default value: 100 ms
Max X-axis angle	The maximum allowed X-axis tilt. If the tilt angle is greater than the entered value,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



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:

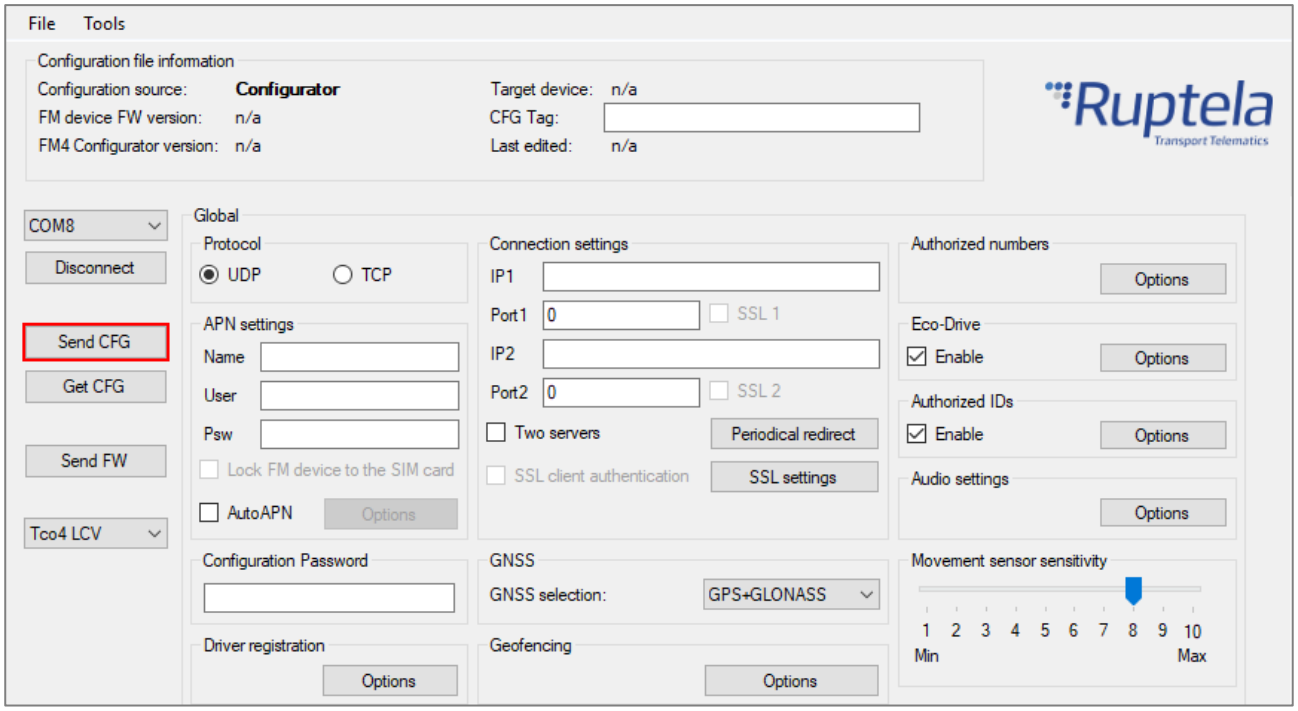
- Shock Duration (**Event on** must be set to *Change*)
- G Peak X
- G Peak Y
- G Peak Z

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.



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.