FM5300 User Manual
DRAFT v0.1

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1 INTRODUCTION

1.1 Attention

⚠	Do not disassemble the device. If the device is damaged, the power supply cables are not isolated or the isolation is damaged, before unplugging the power supply, do not touch the device.
⚠	All wireless data transferring devices produce interference that may affect other devices which are placed nearby.
🔧	The device must be connected only by qualified personnel.
✓	The device must be firmly fastened in the predefined location.
✓	The programming must be performed using a second class PC (with autonomic power supply).
☔	The device is susceptible to water and humidity.
⚡	Any installation and/or handling during a lightning storm are prohibited.
⚠	FM5300 has USB interface; Please use cables provided with FM5300 device. Teltonika is not responsible for any harm caused by using wrong cables for PC <-> FM5300 connection.

1.2 Instructions of safety

This chapter contains information on how to operate FM5300 safely. By following these requirements and recommendations, you will avoid dangerous situations. You must read these instructions carefully and follow them strictly before operating the device!

To avoid mechanical damage, it is advised to transport the FM5300 device in an impact-proof package. Before usage, the device should be placed so that its LED indicators are visible, which show the status of operation the device is in.

When connecting the connection (2x10) cables to the vehicle, the appropriate jumpers of the power supply of the vehicle should be disconnected.

Before dismounting the device from the vehicle, the 2x10 connection must be disconnected.

The device is designed to be mounted in a zone of limited access, which is inaccessible for the operator. All related devices must meet the requirements of standard EN 60950-1.

The device FM5300 is not designed as a navigational device for boats.

1.3   Legal Notice

1.4   About document

This document contains information about the architecture, possibilities, mechanical characteristics, and configuration of the FM5300 device.

Acronyms and terms used in document

PC – Personal Computer.

GPRS – General Packet Radio Service.

GPS – Global Positioning System.

GSM – Global System for Mobile Communications.

SMS – Short Message Service.

AC/DC – Alternating Current/Direct Current.

I/O – Input/Output.

Record – AVL data stored in FM5300 memory. AVL data contains GPS and I/O information

AVL packet - Data packet that is being sent to server during data transmission. AVL packet contains from 1 to 24 records.

Geofence – is a virtual geographic area of interest that can be defined by a radius or polygon for the location. In this document term "Geofence" is often used as functionality, which generates an event when crossing defined area.

2   BASIC DESCRIPTION

FM5300 is a terminal with GPS and GSM connectivity, which is able to determine the object's coordinates and transfer them via the GSM network. This device is perfectly suitable for applications, which need location acquirement of remote objects. It is important to mention that FM5300 has additional inputs and outputs, which let you control and monitor other devices on remote objects. FM5300 also has a USB port for device status log output and entering configurations.

2.1 Package contents[1]

Usually the FM5300 device sample is supplied to the customer in a cardboard box containing all the equipment that is necessary for operation. The package contains:

FM5300 device;
input and output power supply cable with a 2x10 connection pins;
4 screws for assembling device
GPS/GLONASS antenna;
GSM antenna;
USB cable;
Port 1/2 cable
Port 3 cable
card with link to drivers and configurator.

2.2 Basic characteristics

GSM / GPRS features:
- Teltonika TM11Q quad band module (GSM 850 / 900 / 1800 / 1900 MHz);
- GPRS class 10;
- SMS (text, data).

GPS features:
- GPS/GLONASS receiver
- Protocol NMEA-0183:;
- Up to -161 dBm sensitivity.

Hardware features:
- Cortex®-M3 processor;
- 4 MB internal Flash memory;
- Built-in accelerometer.

Interface features:
- Power supply: 10 ÷ 30V;
- USB port;
- 4 digital inputs;
- 4 analog input;
- 4 open collector digital outputs;
- 1Wire® temperature sensor
- 1Wire® iButton
- LEDs indicating device status.
- 2xRS232 ports
- Audio interface

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[1] Package content depends on Order Code, and can be customized by customer needs.

2.3 Mechanical features

Table 1 FM5300 physical interfaces and operation environment

Part name	Physical specification	Operation environment
Navigation LED	LED	
Modem LED	LED	
GPS	GPS antenna connector MCX	
GSM	GSM antenna connector SMA female outer shell, female inner pin	Operation temperature: -25⁰C … +55⁰C Storage temperature: -40⁰C … +70⁰C Storage relative humidity 5 … 95 % (non condensating)
Socket 2x10	Tyco Micro MATE-N-LOK™ or similar	
USB	Mini USB socket	
Port1	RS232 port channel 1 (RJ45 socket)	
Port2	RS232 port channel 1 (RJ45 socket)	
Audio port	RJ11	
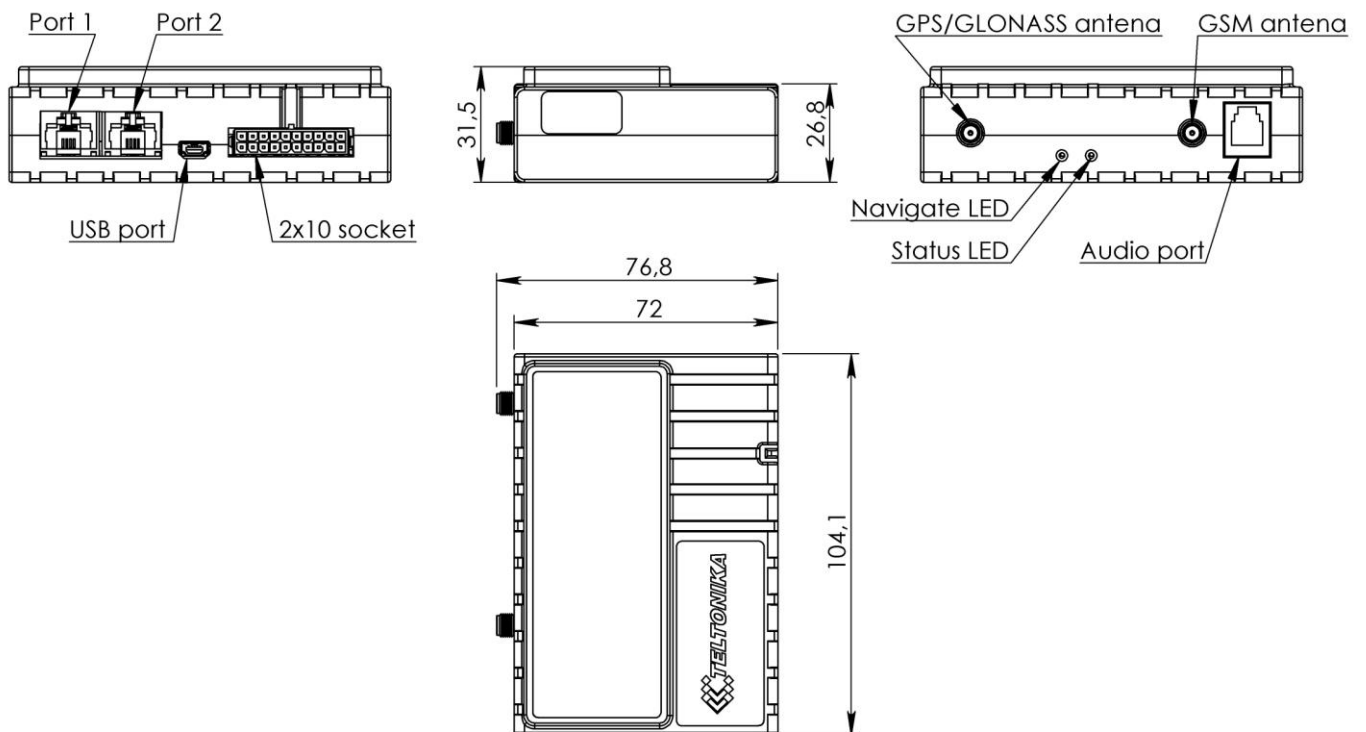
Figure 1. FM5300 view & dimensions in mm (tolerance ±2mm)

2.4 Electrical characteristics

Table 2 Electrical characteristics

CHARACTERISTIC DESCRIPTION / VALUE	Min.	Typ.	Max.	Unit
SUPPLY VOLTAGE				
Supply Voltage (Recommended Operating Conditions)	11.8	-	30	V
Supply Voltage (for internal rechargable battery charging proper functioning)	9.5	-	30	V
POWER SUPPLY CURRENT (HARDWARE VERSION WITH INTERNAL BATTERY)				
Deep Sleep, average, Icc.ds	-	1.5	4	mA
Ucc=12.6V, all modules fully working, internal battery is charging, Icc1	-	-	315	mA
Ucc=12.6V, all modules fully working, internal battery is charged, Icc2	-	-	245	mA
Ucc=25.2V, all modules fully working, internal battery is charging, Icc3	-	-	158	mA
Ucc=25.2V, all modules fully working, internal battery is charged, Icc4	-	-	123	mA
SUPPLY CURRENT (HARDWARE VERSION WITH EXTERNAL BATTERY)				
Deep Sleep, average, Icc.ds	-	1.5	4	mA
Ucc=12.6V, all modules fully working, internal battery is charging, Icc5	-	-	566	mA
Ucc=12.6V, all modules fully working, internal battery is charged, Icc6	-	-	245	mA
Ucc=25.2V, all modules fully working, internal battery is charging, Icc7	-	-	283	mA
Ucc=25.2V, all modules fully working, internal battery is charged, Icc8	-	-	123	mA
DIGITAL OUTPUT (OPEN DRAIN GRADE)				
Drain current (Digital Output OFF)	-	-	120	uA
Drain current (Digital Output ON, Recommended Operating Conditions)	-	-	300	mA
Static Drain-Source resistance (Digital Output ON)	-	-	300	mOhm
DIGITAL INPUTS				
Input resistance (DIN1, DIN2, DIN3)	15	-	-	kOhm
Input Voltage (Recommended Operating Conditions)	0	-	Supply voltage	V

CHARACTERISTIC DESCRIPTION / VALUE	Min.	Typ.	Max.	Unit
Input Voltage threshold (DIN1)	-	7,5	-	V
Input Voltage threshold (DIN2, DIN3, DIN4)	-	2,5	-	V
ANALOG INPUTS				
Input Voltage (Recommended Operating Conditions), Range1	0	-	10	V
Input resistance, Range1	-	120	-	kOhm
Input Voltage (Recommended Operating Conditions) Range2	0	-	30	V
Input resistance, Range2	-	147	-	kOhm
OUTPUT SUPPLY VOLTAGE 1-WIRE[2]				
Supply Voltage	3,3	-	3,9	V
Output inner resistance	-	7	-	Ohm
Output current (U_{out} > 3.0V)	-	30	-	mA
Short circuit current (U_{out} = 0)	-	130	-	mA
CAN INTERFACE				
Internal terminal resistors CAN bus	-	No	-	Ohm
Differential input resistance	19	30	52	kOhm
Recessive output voltage	2	2.5	3	V
Differential receiver threshold voltage	0.5	0.7	0.9	V
Common mode input voltage	-30	-	30	V

[2] 1-wire Supply voltage PIN is dedicated for 1-wire devices ONLY, do not use it for any other purpose.

2.5 Absolute Maximum Ratings

Table 3 Absolute maximum ratings

CHARACTERISTIC DESCRIPTION / VALUE	Min.	Typ.	Max.	Unit
Supply Voltage (Absolute Maximum Ratings)	-32		32	V
Digital output clamp threshold voltage (Absolute Maximum Ratings), (I_{drain} = 2mA)	36			V
Digital Input Voltage (Absolute Maximum Ratings)	-32		32	V
Analog Input Voltage (Absolute Maximum Ratings)	-32		32	V
Voltage on Supply Voltage 1-Wire (Absolute Maximum Ratings)	0		10	V
Voltage on Data Input/Output 1-Wire (Absolute Maximum Ratings)	0		10	V
Voltage on CANH, CANL (Absolute Maximum Ratings)	-58		58	V

3 CONNECTION AND PINOUT

3.1 SIM card insert scheme
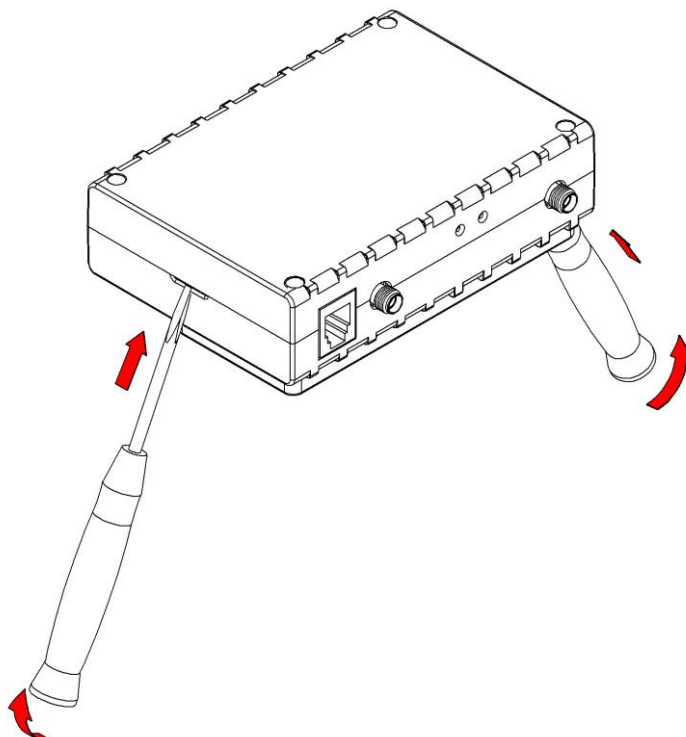
①

Gently open FM5300 case using screwdrivers
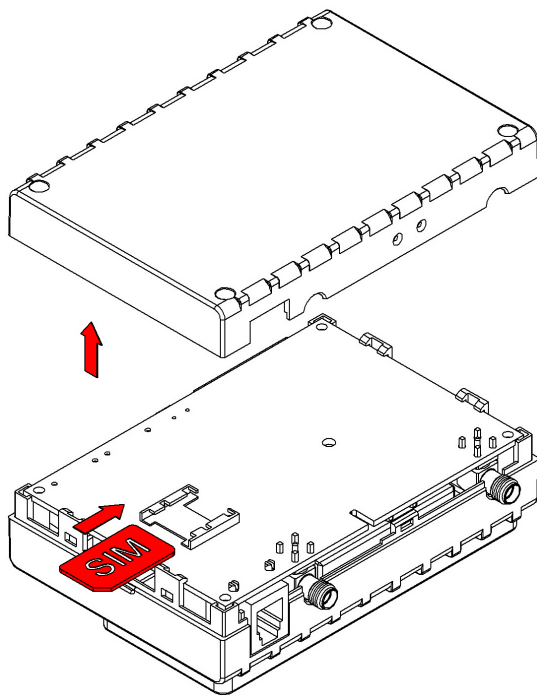
②

Take off FM5300 case and insert SIM card as shown
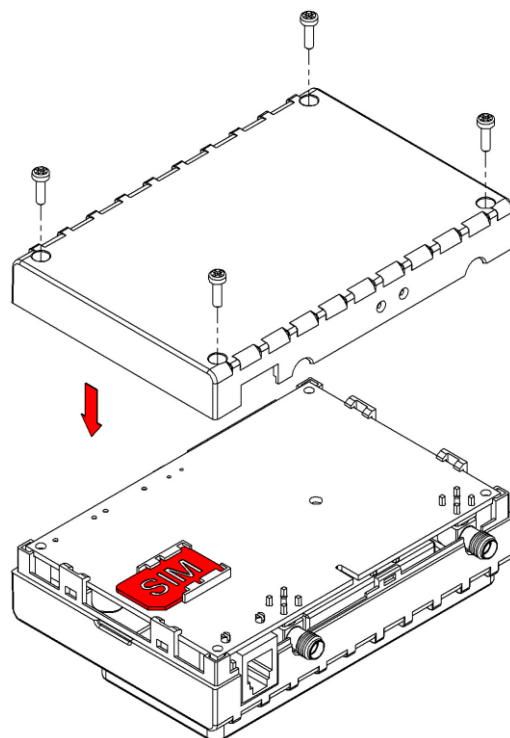
③

Assemble device as shown and put screws into the holes
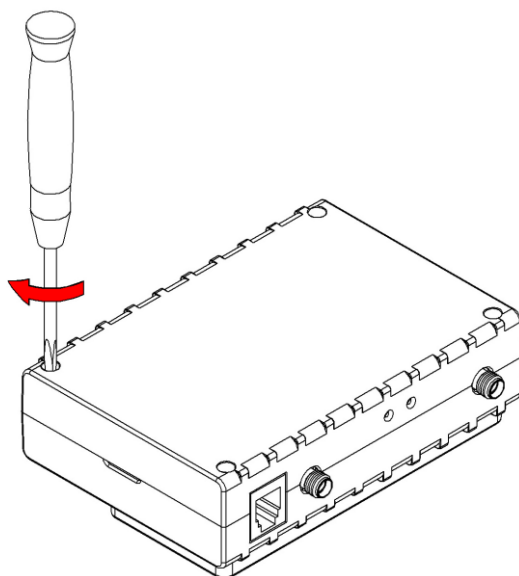
④

Screw all 4 screws
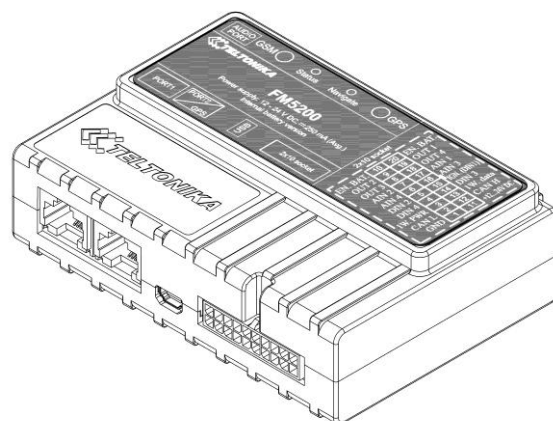
⑤

Device is ready

3.2 Installing FM5300 drivers

Software requirements
   • Operating system 32-bit and 64-bit: Windows XP with SP3 or later, Windows Vista, Windows 7.
   • MS .NET Framework V3.5 or later (http://www.microsoft.com or http://avl1.teltonika.lt/downloads/tavl/Framework/dotnetfx35setupSP1.zip).

Drivers
   Please download Virtual COM Port drivers from Teltonika website: http://avl1.teltonika.lt/downloads/FM11/vcpdriver_v1.3.1_setup.zip

Installing drivers
Extract and run VCPDriver_V1.3.1_Setup.exe. This driver is used to detect FM5300 device connected to the computer. Click 'Next' in driver installation window (figures below):
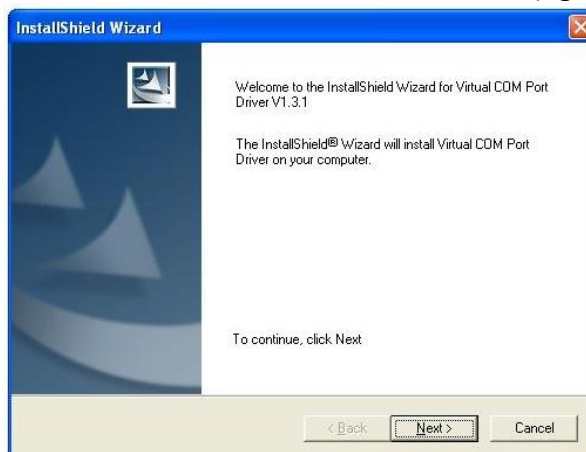
Figure 2. Driver installation window

This will launch device driver installation wizard. In the following window click 'Next' button again:

Figure 3. Driver installation window

Setup will continue installing drivers and will display a window about successful process in the end. Click 'Finish' to complete setup:

Figure 4. Driver installation window

You have now installed drivers for FM5300 device successfully.

3.3 Navigate LED

Table 4 Navigate LED operation

Behaviour	Meaning
Permanently switched on	GPS signal is not received
Blinking every second	Normal mode, GPS is working
Off	GPS is turned off because: • Deep sleep mode Or • GPS antenna short circuited

3.4 Status LED

Table 5 Status LED Operation

Behaviour	Meaning
Blinking every second	Normal mode
Blinking every 2 seconds	Deep sleep mode
Blinking fast for a short time	Modem activity
Blinking fast constantly	Boot mode
Off	• Device is not working Or • Device firmware being flashed

3.5 Socket 2×10 pinout

```
(−)EXT. BAT    10  □ □   20   (+) EXT. BAT
     OUT 2      9  □ □   19   OUT 1
     OUT 3      8  □ □   18   OUT 4
     AIN 2      7  □ □   17   AIN 1
     AIN 4      6  □ □   16   AIN 3
     DIN 2      5  □ □   15   DIN 1
     DIN 4      4  □ □   14   DIN 3
   1W. PWR      3  □ □   13   1W. data
     CAN L      2  □ □   12   CAN H
    (−)GND      1  □ □   11   (+)VCC (10÷30)V DC
```
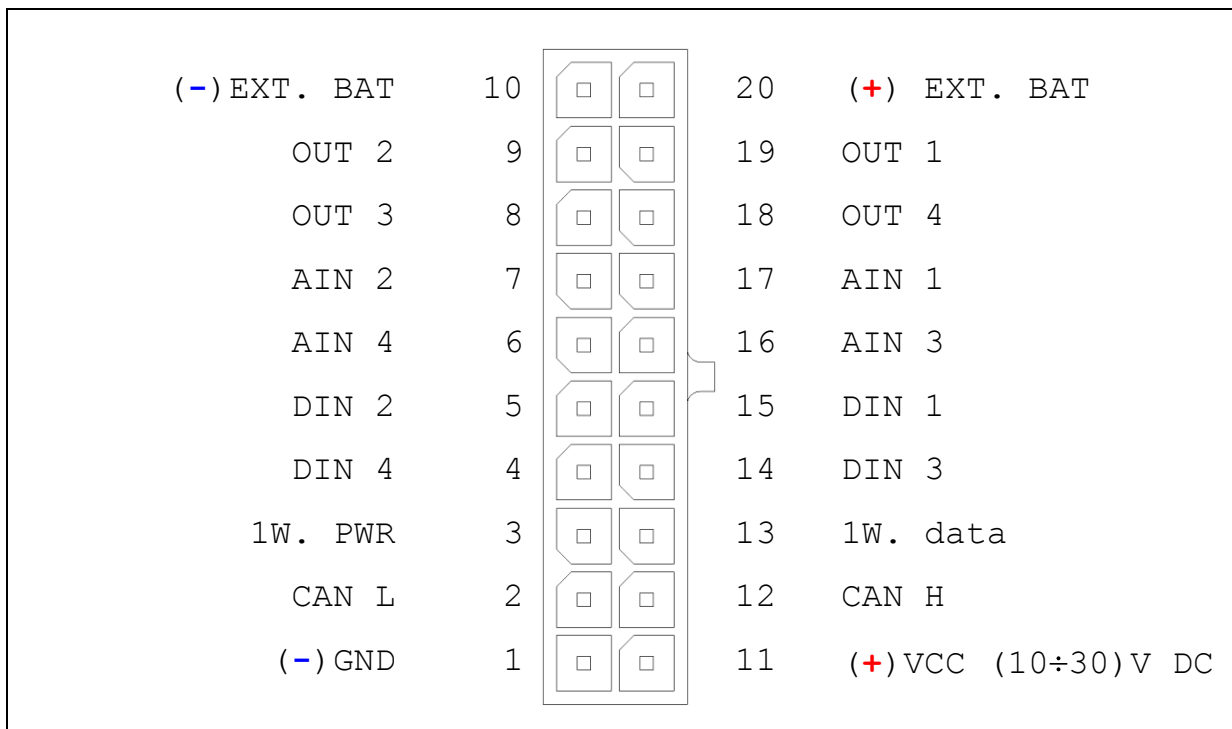
Figure 5 2x10 socket pinout

Table 6 2x10 SOCKET PINOUT DESCRIPTION

Pin Nr.	Pin Name	Description
1	(-)GND	(-) Ground pin. (10…30) V DC*
2	CAN L	SAE J1939 CAN interface Low channel
3	1W. PWR	Power supply pin for Dallas 1-Wire® devices
4	DIN 4	Digital input. Channel 4
5	DIN 2	Digital input. Channel 2
6	AIN 4	Analog input, channel 4. Input range: 0 - 30V/ 0 - 10V DC
7	AIN 2	Analog input, channel 2. Input range: 0 - 30V/ 0 - 10V DC
8	OUT 3	Digital output. Channel 3. Open collector output
9	OUT 2	Digital output. Channel 2. Open collector output
10	Ext. Battery (—)	This pin is used connected with pin 20 (Ext. Battery (+)). Function of those pins is to disconnect the internal accumulator during shipment or storage. When pin 10 and pin 20 are connected, the internal accumulator is on, while disconnected – the internal accumulator is off.
11	(+)VCC (10...30) V DC	Power supply pin
12	CAN H	SAE J1939 CAN interface High channel
13	1W. data	Data channel for Dallas 1-Wire® devices
14	DIN 3	Digital input, channel 3
15	DIN 1	Digital input, channel 1 (RESERVED FOR IGNITION LINE)
16	AIN 3	Analog input, channel 3. Input range: 0 - 30V/ 0 - 10V DC
17	AIN 1	Analog input, channel 1. Input range: 0 - 30V/ 0 - 10V DC

Pin Nr.	Pin Name	Description
18	OUT 4	Digital output. Channel 4. Open collector output
19	OUT 1	Digital output. Channel 1. Open collector output
20	Ext. Battery (+)	This pin is used connected with pin 10 (Ext. Battery (—)). Function of those pins is to disconnect the internal accumulator during shipment or storage. When pin 10 and pin 20 are connected, the internal accumulator is on, while disconnected – the internal accumulator is off.

3.6 USB

FM5300 connected to PC creates STM Virtual COM Port, which can be used as system port (to flash firmware and configure the device).
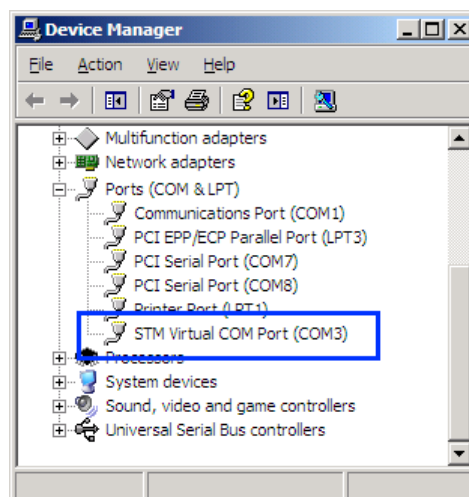
Figure 6. COM-Ports

4   FIRMWARE

4.1   Updating firmware using USB cable

FM5300 functionality is always improving, new firmware versions are developed. Current module firmware version can be retrieved from configurator. See configuration description for details.

Contact sales manager to get the latest firmware.

Updater is needed to update the firmware. It can be downloaded from:
http://avl1.teltonika.lt/downloads/FM53/

Firmware must to be copied to "Firmware updater" folder.

Connect FM5300 to PC with USB cable. Launch "Firmware Updater", select COM port, click connect and update. Update process may take up to several minutes.
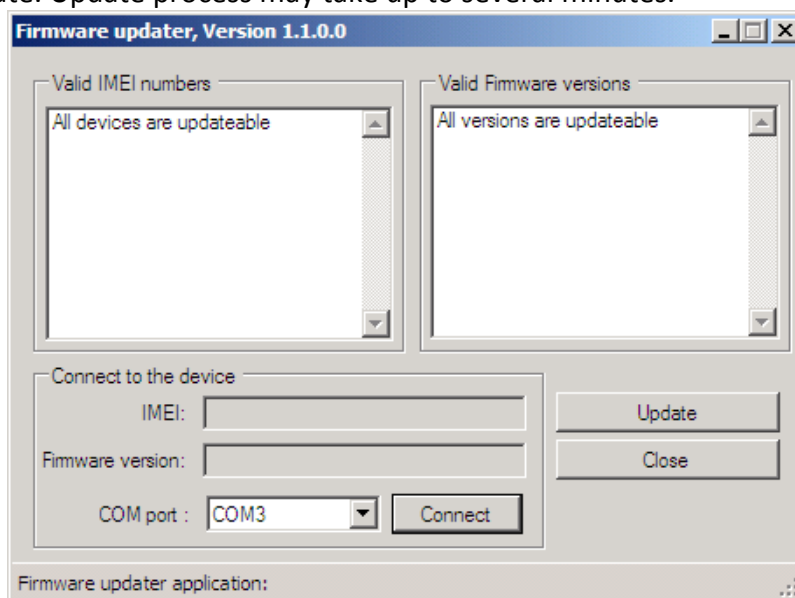
Figure 7. FM updater screen
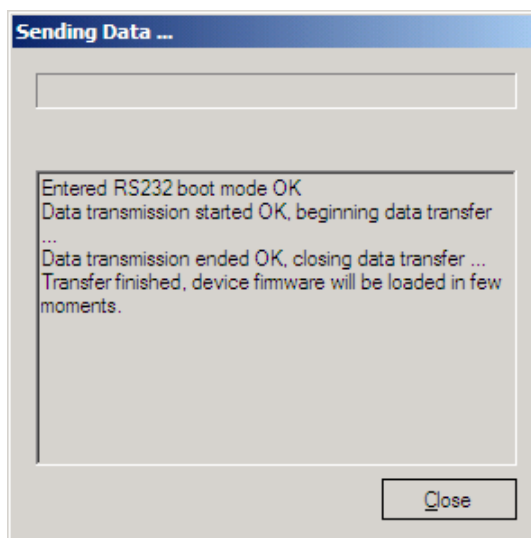
Figure 8. FM firmware updating finished

4.2 Updating firmware via GPRS

Firmware can also be updated over GPRS using RILS system.

RILS stands for Remote Imlet Loading System, which is used to update FM5300 processor firmware. In order to update firmware, server sends a SMS to the FM5300 and directs it to connect to the server and download new firmware. The special web interface is used for this operation. Address of the web application is: http://212.47.99.62:5002/RILS-web/.

For RILS login and password please contact your sales manager.

Figure 9. Remote Configuration

After logging in click on 'Upload FM4', click Browse, select FM5300 firmware file from hard disk, click OK and then Upload. Select uploaded firmware from the list (last one) and click next. Enter necessary parameters in the fields:

1. Server IP: 212.47.99.62
2. Server port: 5009
3. Module number is GSM number of FM SIM in worldwide standard, for example: +37069912345.

Enter your APN, APN (chap) login and password. After entering all parameters, click 'Add Module'. To operate multiple devices, enter new IMEI and GSM number and click 'Add Module' again. Otherwise click 'Next' and if all data is correct, in next window click 'Upload'.

5 OPERATIONAL BASICS

5.1 Operational principles

FM5300 module is designed to acquire records and send them to server. Records contain GPS and I/O information. Module uses GPS receiver to acquire GPS data and is powered with 3 data acquire methods: time-based, distance-based, angle-based methods. Method's details are described in **Data Acquisition** 8 chapter. All data is stored in flash memory and later can be sent via GPRS or SMS channels. GPRS mode is most preferred data sending mode. SMS mode is mostly used in areas without GPRS coverage or GPRS usage is too expensive.

GPRS and SMS settings are described in **Data Sending – GPRS 6.3.2.2.1** and **Data Sending – SMS** 6.3.2.2.2 chapters. FM5300 communicates with server using special data protocol. Data protocol is described in "FMXXXX Protocols" document and in 9.1 chapter.

FM5300 can be managed by SMS commands (SMS Command list is described in SMS Command List section) and GPRS commands (GPRS Command list is described in GPRS Command List section). Module configuration can be performed over TCP or via SMS. Configuration parameters and modes are described in "FMXXXX Protocols" document.

5.2 Operational Modes

FM5300 is designed to operate in two different modes: Normal Mode and Deep Sleep Mode (Standby mode). Normal Mode means that FM5300 is fully functional and performs all the functionality mentioned above in Operational principals section.

Deep Sleep Mode is designed to dramatically reduce power consumption. It is separate mode and certain conditions must be fulfilled to switch from Normal operation and enter this mode. Detailed information about how FM5300 enters/exits Deep Sleep Mode and what functions does FM5300 perform while in this mode will be found in 11 chapter.

5.3 Accelerometer

FM5300 has a built in 3 axis accelerometer which allows device to indicate if vehicle is moving or not as well as measure acceleration. Accelerometer sensitivity can be configured – it has 3 configurable global parameters: Movement Sensitivity and start/stop timeouts define time intervals in seconds. To indicate that vehicle is moving, FM5300 constantly (in frequency of 10 Hz) checks for g force change on X, Y and Z. If measured g force keeps exceeding the defined limit in "Movement Sensitivity" (Figure 10) for defined time interval in "Movement Filter Start" field, then vehicle is considered as moving. Same settings for idle indication apply – if g force change is less than the one defined in "Movement Sensitivity" field for time interval defined in "Movement Filter Stop" field, then vehicle is considered as idle (not moving).

Example for default parameters: Movement Filter Start = 1 and Movement Filter Stop = 30 means that movement will be detected after 1 second and stop will be detected after 30 seconds of inactivity.
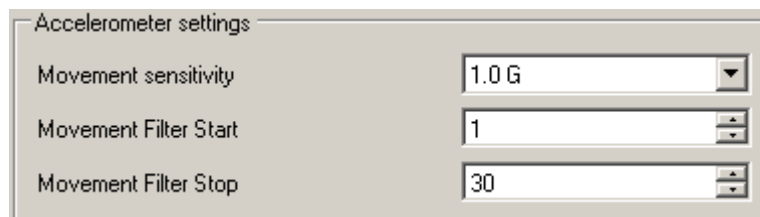
Figure 10. Accelerometer settings

5.4 Virtual Odometer

Virtual odometer is used to calculate travelled distance in FM5300 as a separate I/O element. When FM5300 detects movement, it starts counting distance using GPS signal: every second it checks current location and calculates distance between current and previous point. It keeps adding these intervals until it is time to make a record, then FM5300 records its location and adds odometer value, which is equal to the sum of all distances, measured every second. When record is made, odometer resets to zero and distance calculation starts all over again.

Virtual odometer as an I/O element can be also used with Trip feature, read chapter 5.7.2.

5.5 Voice Functionality

FM5300 has functionality to receive and make voice calls. To enable this functionality telephone handset with electret microphone and RJ-11 connector must be connected to "Audio" port.

In "Global Parameters", "Call Settings" section (Figure 11) has four parameters: "Call number", "Call trigger", "Ringtone", and "Auto answer". To initiate a call an appropriate digital input has to be selected as a "Call Trigger". To trigger the call selected input has to be connected to the ground. When the call is triggered, FM5300 dials the number which is defined in "Call Number" field. To initiate a call to FM5300 dial a number of the SIM card that is inserted in FM5300. When FM5300 has an incoming call it can play a selected tone from the "Ringtone" list. FM5300 will auto answer the call after number of rings defined in "Auto answer" field.

"Voice Settings" (Figure 11) section includes settings for "Microphone level" to regulate microphone sensitivity and "Speaker level" to define how load will be the speaker.

For detailed "Voice Functionality" configuration parameters descriptions refer to chapter 5.5
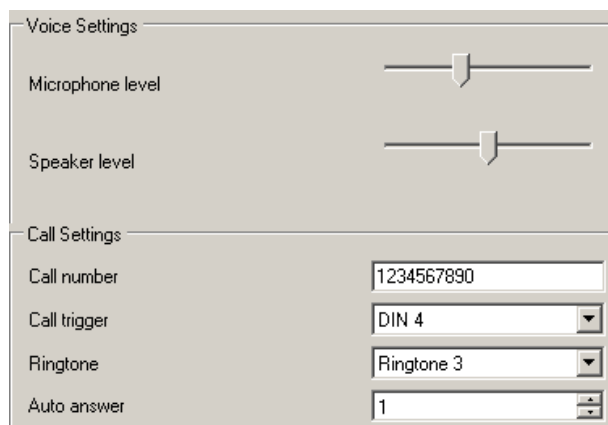
Figure 11. Voice and Call Settings

5.6 Profiles

FM5300 has 4 profiles saved in Flash memory of the module. Every profile has a list of parameters, which enables FM5300 to operate in different modes while using different profiles. The easiest way to understand what is profile is to compare it to a list of instructions that are written for different cases. You are allowed to setup up to 4 different module behaviours. Global parameters contain settings that are common for all 4 profiles. This means that if FM5300 is set to call to predefined number, you will be able to call it while using any profile.

Profile 3 is default profile for FM5300. It is always loaded on very first start-up and further profile switching is proceeded after operator scan or I/O element changes.

Switching between profiles (changing behaviour) can be performed by GSM Operator (mostly used for roaming applications), or by Profile switching depending on I/O Event (on I/O value changing). More information about Profile switching functionalities can be found in chapters 7.1 (switching by GSM Operator) and (switching by I/O Element) 7.2.

5.7 Features

Using available features can greatly increase FM5300 usability options.

5.7.1 Scenarios

Four scenarios are available on FM53 device:
 a. Digital Output No.1 is used by scenarios - Eco Driving **or** Over Speeding;
 b. Digital Output No.2 is used by scenarios - Authorized Driving **or** Immobilizer.

Eco Driving Scenario. Gives the ability to periodically monitor driving characteristics and warn the driver against over accelerating, braking or cornering. This scenario also features adaptive and auto calibration. More about Eco Driving read in chapter 12.1

Over Speeding Scenario. Helps to prevent from exceeding fixed speed and inspects driver if needed. DOUT1 is controlled by scenario for user needs, to manage buzzer, LED etc.

Authorized Driving Scenario. Gives ability to use vehicle only for 50 specific iButton owners (specified in iButton list). DOUT2 is controlled by scenario for user needs, to manage buzzer, LED etc.

Immobilizer Scenario. Vehicle can be used only if iButton is connected. In this scenario iButton list is not used; connect any iButton to pass Immobilizer security. DOUT2 is controlled by scenario for user needs.

5.7.2 Trip

Trip customizable feature enables user extended monitoring of performed trips (from engine start at present location to engine stop at arrived location), log their start and stop points, view driven total distance. Event will be **generated (included into send records) only** when trip starts and finish.

5.7.3 Geofencing

Geofencing is another feature which is highly customizable and can detect wherever car enters or leaves customized areas. More about Geofencing can be read in 5.7.3 chapter.

Auto Geofencing feature if enabled is activated automatically by turning off car ignition. Next time before driving user has to disable Auto Geofencing with iButton or by turning on car ignition. In case of theft car leaves Auto Geofencing zone without authorization FM5300 device automatically sends high priority record to AVL application.

5.7.4 iButton list

IButton list is used to enter authorized iButton ID codes, which are used to authenticate driver in Authorized driving and Auto Geofencing options.

6 CONFIGURATOR

6.1 STARTUP

FM5300 configuration is performed via FM5300 Configurator program. FM5300 Configurator version can be downloaded from http://avl1.teltonika.lt/downloads/FM53/. Contact sales manager to get the latest FM5300 Configurator version. FM5300 configurator operates on Microsoft Windows OS and uses MS .Net Framework 3.5 or higher. Please ensure that MS .Net Framework 3.5 or later is installed on your PC before starting configurator. Latest MS .Net Framework version can be downloaded from official Microsoft web page.

Module configuration is performed over USB cable or COM1. Configuration process starts from starting FM5300 Configurator program and then connecting to FM5300 device via "Connect" button located on the top left corner of configurator. If one of the communication sources (USB cable or COM1) is connected to the device configurator will detect it automatically and if connected successfully IMEI, Version fields which were empty, now are filled with certain numbers depending on Modem IMEI and firmware version of your device (Figure 12).
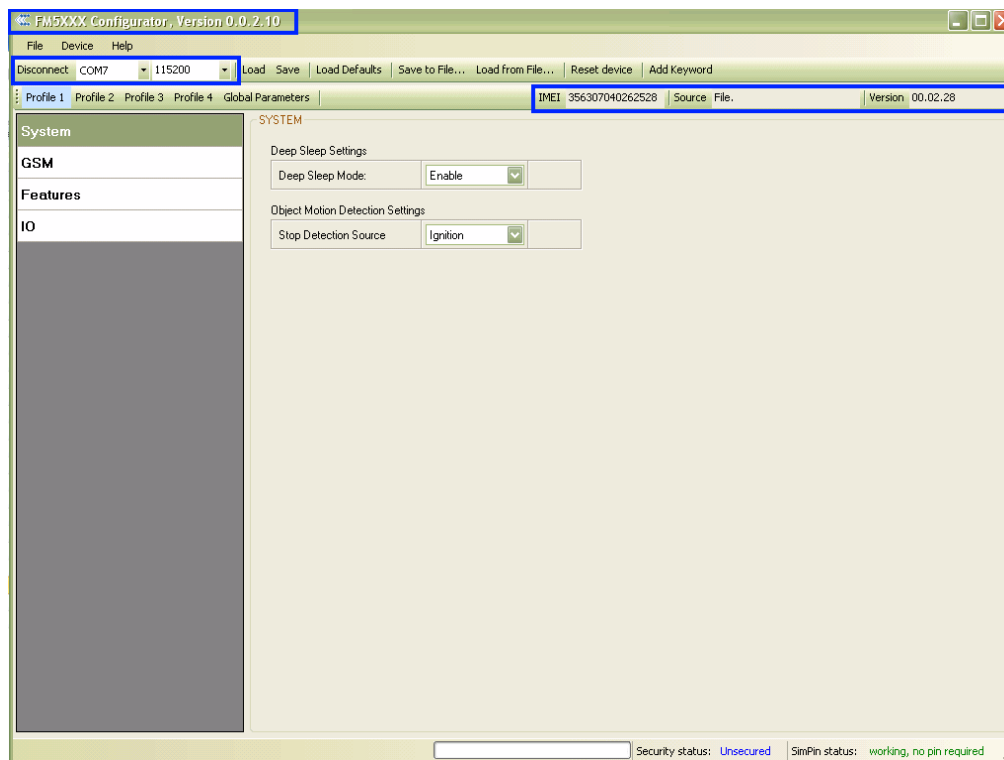
Figure 12. FM5300 Configurator window

If both USB cable and COM1 are connected to the device you will be prompted to select communication source (Figure 13).
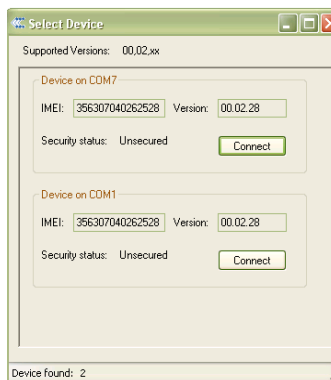
Figure 13. FM5300 Communication source selection

6.2 Configurator structure

FM5300 has four user editable profiles, which can be both loaded and saved to the device. User can also revert to default settings, by pressing Load Defaults button. After any modification of configuration settings it has to be saved to FM5300 device, otherwise it will not be written to device flash memory.

FM5300 Configurator is divided into 5 main areas (Figure 14):
- Buttons area;
- Information area;
- Profiles or global parameters selection area;
- Settings menu;

- Configurable parameters and values menu.
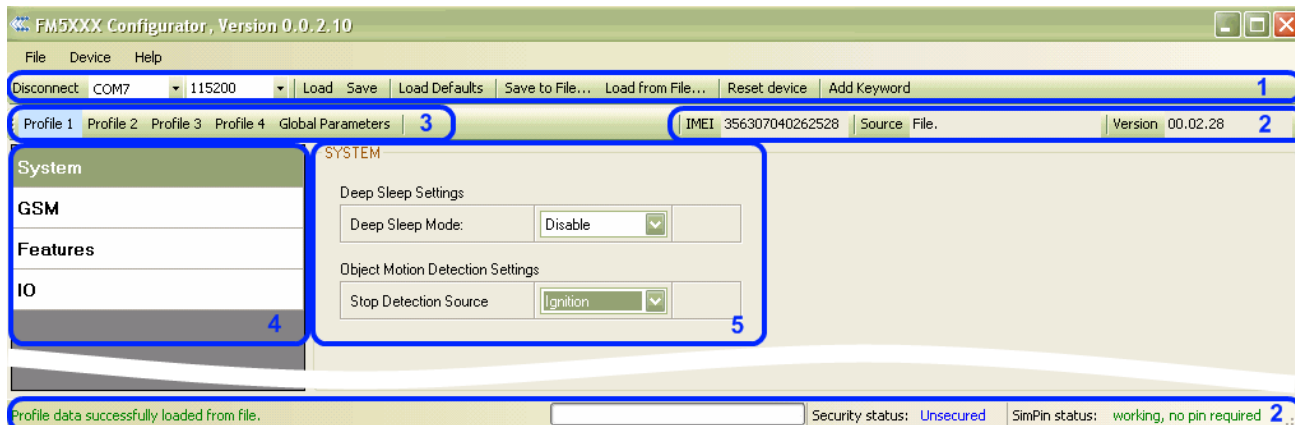
Figure 14. FM5300 Configurator window structure

6.2.1 Buttons area

Table 7 Configurator buttons area description

Main Buttons	
Button	**Description**
Connect	connects the device
Load	reads configuration parameters from FM5300 Flash memory
Save	saves configuration parameters to FM5300 Flash memory
Load Defaults	loads default FM5300 settings that later can be modified
Save to File…	allows user to save currently entered settings to .XML file for later usage
Load from File…	allows user to load configuration saved in .XML extension file
Reset device	reboots FM5300 and displays processor firmware version
Additional Buttons	
Button	**Description**
SIM PIN	allows to enter PIN code if inserted SIM card has activated PIN code security
Add Keyword[3] / Change Keyword / Switch Security Off	buttons are used to protect configurator from unauthorized access to configuration

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[3] Keyword is 4 -10 symbol length. It If keyword is set, every time user reconnects FM5300 to USB or COM1 port he will be asked to enter valid keyword when connecting FM5300 to configurator. User is given 5 attempts to enter valid keyword before blocking configurator.

6.2.2 Information area

FM5300 information area is divided into 2 parts located on the top right and bottom of the configurator. When configurator is connected to the device via USB or COM1 port all necessary information about device is shown here:

- IMEI – unique number for every FM5300 and usually servers recognize different devices by this number;
- SOURCE – configuration source (device or file);
- VERISON – firmware version of the device;
- STATUS – status bar
- SECURITY STATUS – status of the configurator security;
- SIMPIN STATUS – status of SIM card in the device

6.2.3 Profiles/global parameters selection area

FM5300 has 4 user editable profiles stored in Flash no. 1-4 memories and one extra profile stored in Flash no. 0 which cannot be edited by user. Profile from Flash no. 0 is used by system and cannot be selected as active, while profiles from Flash no. 1-4 are fully editable and can be selected as active.

Reading profiles and Global parameters from Flash memory is very simple procedure. By pressing "Load" button all 4 profiles and Global parameters are loaded to the configurator (Figure 15). To configure 3rd profile choose a TAB named "Profile 3" and all configurable parameters of this profile will be available to change.
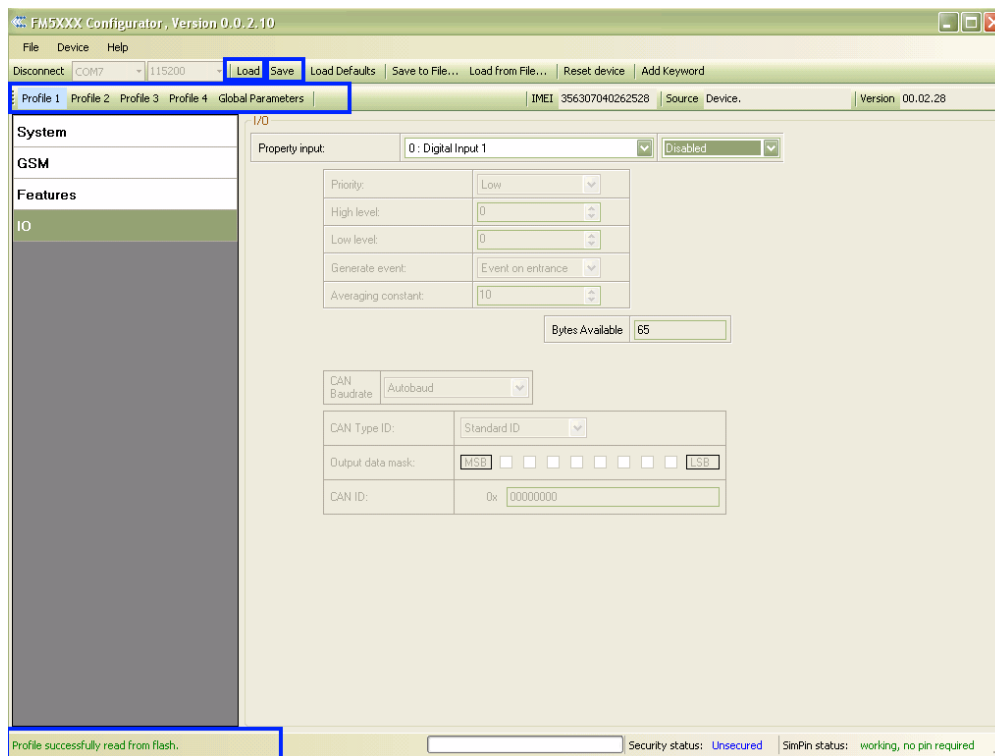
Figure 15. FM5300 Configurator profiles loading window

After changing profile and global parameters, changes can be saved to FM5300 Flash. By pressing "Save" button all 4 profiles and Global parameters are saved to the Flash (Figure 16).

Figure 16 FM5300 Configurator profiles saving information

6.3 Parameters Configuration

6.3.1 Global parameters Settings

Global parameters do not depend on selected profile; they are common for all profiles. To configure these parameters choose a TAB named "Global Parameters" and make all necessary changes (Figure 17)
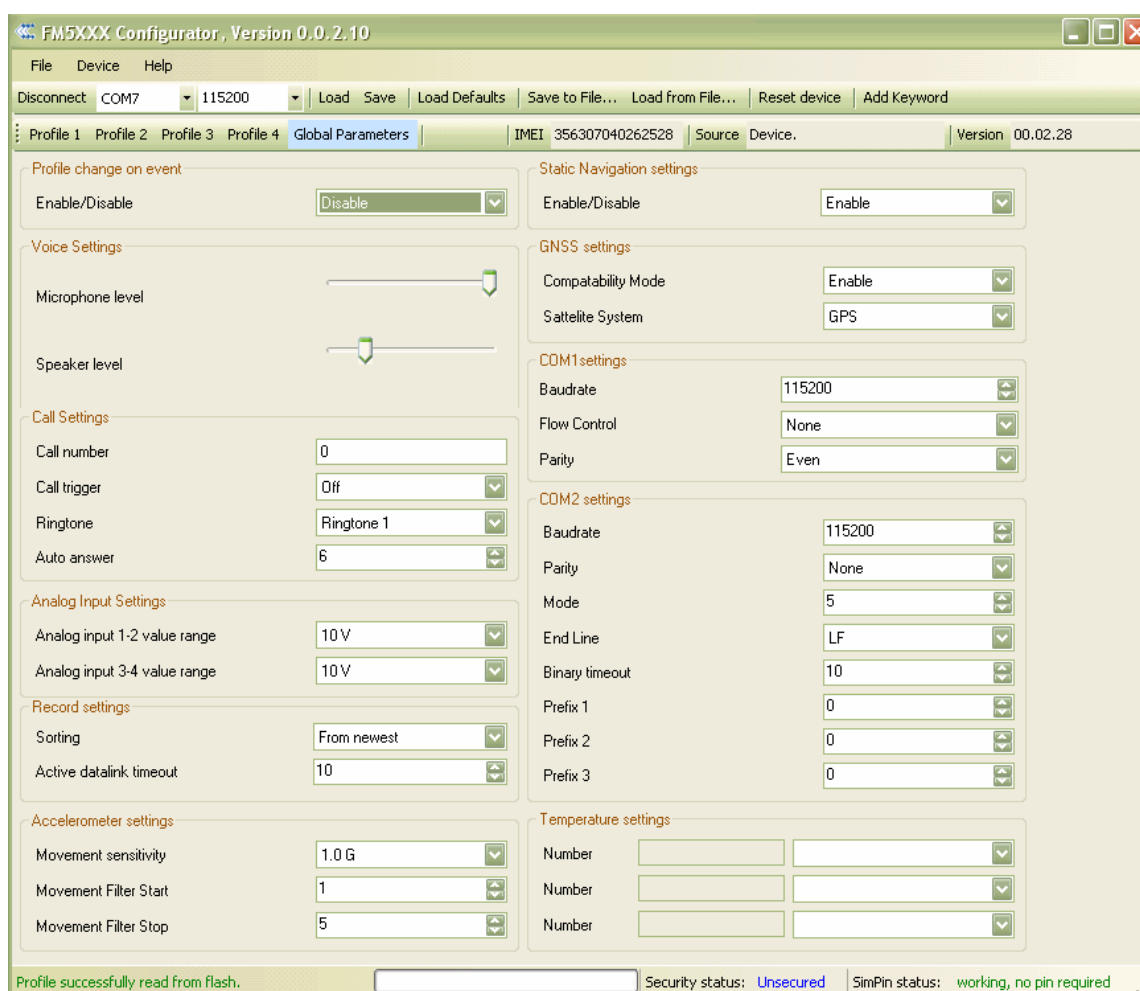
Figure 17. FM53 Global parameters

Table 8 Global parameters description

Parameter Name	Parameter description
Profile change on event	Allows selecting profile switching method. When 'Profile change on event' is disabled – FM5300 switches profiles depending on GSM operator code method. Otherwise it switches profiles depending on I/O events (see details in chapter 7).
Voice settings	Allows to setup microphone sensitivity and speaker loudness level.

Parameter Name	Parameter description
Call Settings	Allows entering one number to which FM5300 will be able to call to. Call trigger defines input, which will be used to receive or make a call. Usually to that input a button is connected ("Digital Input 1" is not allowed, because this input is dedicated for ignition).
Record Settings	Are used to switch between two data sending modes: starting from newest records or starting from oldest record. Active data link timeout defines how many seconds should FM5300 keep connection to the server before disconnecting after successful data transfer. Note that even if it disconnects from server, it always keep active GPRS session.
Analog input settings	Defines maximum input voltage on analog input. Possible cases are: all inputs 0-30V, 0-10V, two inputs 0-10V while other two 0-30V maximum input range has impact on precision – values on 0-10V input are measured more precisely than 0-30V (higher resolution).
Accelerometer settings	Defines accelerometer sensitivity range (0.5g, 1g, 1.5, 2g), how many seconds should movement be detected by accelerometer in order to set movement for FM5300 application and how many seconds after movement is not detected by accelerometer FM5300 application should treat like movement is still there.
Static Navigation settings	Allows enabling or disabling functionality.
GNSS Settings	Allows choosing compatibility mode and satellite System.
COM1 Settings	Allows configuring COM1 baud rate, parity and flowing control.
COM2 Settings	Allows configuring COM2 baud rate, parity mode, end line, binary timeout and 3 prefixes.
Temperature Settings	When two or three temperature sensors are connected to FM5300 it is necessary to define sensor ID to certain property separately. This way FM5300 will know which temperature sensor is which property. FM5300 automatically updates ID's field if any sensors are connected while configuring device via configurator.

6.3.2   Settings and configurable parameters menu

Every FM53 profile has four main groups of parameters:
1. System – main parameters for all device;
2. GSM has 3 subgroups
    a. GPRS
    b. SMS
    c. OPERATOR LIST
3. Features
4. IO

6.3.2.1 System Settings
System settings have 2 configurable parameters (Figure 18):
*   Deep sleep settings, where user can turn deep sleep on or off.

- Object Motion Detection Settings, where user can configure 3 ways how FM5300 will detect stopped movement. This parameter is used for autogeofencing.
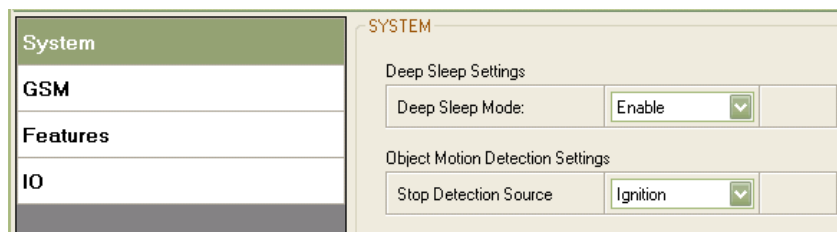
Figure 18. System Settings Configuration

6.3.2.2 GSM Settings

6.3.2.2.1 GPRS

'GPRS' define main parameters for FM5300: GSM operator APN and GPRS username and password (optional – depending on operator), destination server Domain (can be entered either IP or domain name) and port. Also both TCP and UDP protocols are supported.

Some operators use specific authentication for GPRS session – CHAP or PAP. If any of these is used, APN should be entered as '`<APN>:c`' or '`<APN>:p`'. I.e. if operator is using APN 'internet' with CHAP authentication, it should be entered as '`internet:c`'. Information about APN and authentication type should be provided by your GSM operator.
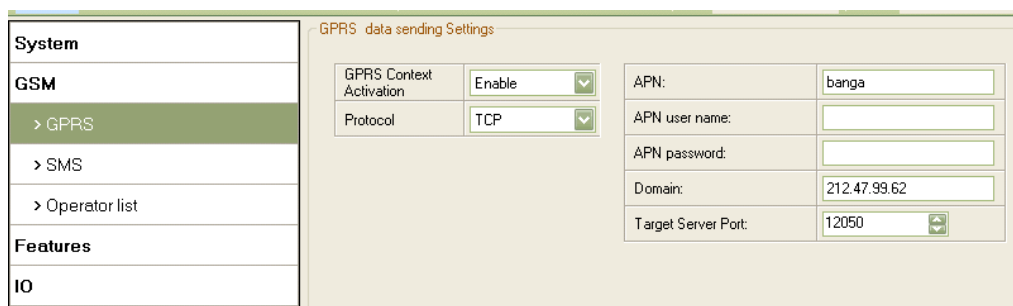
Figure 19. GSM->GPRS Settings Configuration

6.3.2.2.2 SMS

Essential fields in 'SMS' part is 'Login' and 'Password' (Figure 20). This login and password is used with every SMS sent to FM5300. If login and password are not set, every SMS sent to FM5300 device has to include two spaces before command (<space><space><command>).

Command structure: *<login><space><password><space><command>.*

Examples:
1. SMS login and password are set - "asd 123 getgps"
2. SMS login and password are not set - " getgps"

Phone numbers has to be written in international standard, without using "+" or "00" signs in prefix. **If none numbers are entered configuration and commands SMS are allowed to be sent from all GSM numbers.**
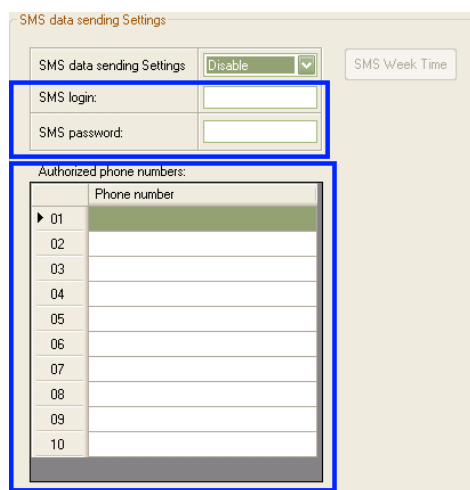
Figure 20. GSM->SMS Settings Configuration (1)

SMS data sending Settings enables or disables **periodic** data and event SMS sending to server (Figure 21). Configuration is divided into 3 main parts:

1. Enable/Disable functionality;
2. SMS Week Time button (can be pressed only if functionality is Enabled);
3. Server Phone Number (has to be written in first position of Authorized phone numbers);
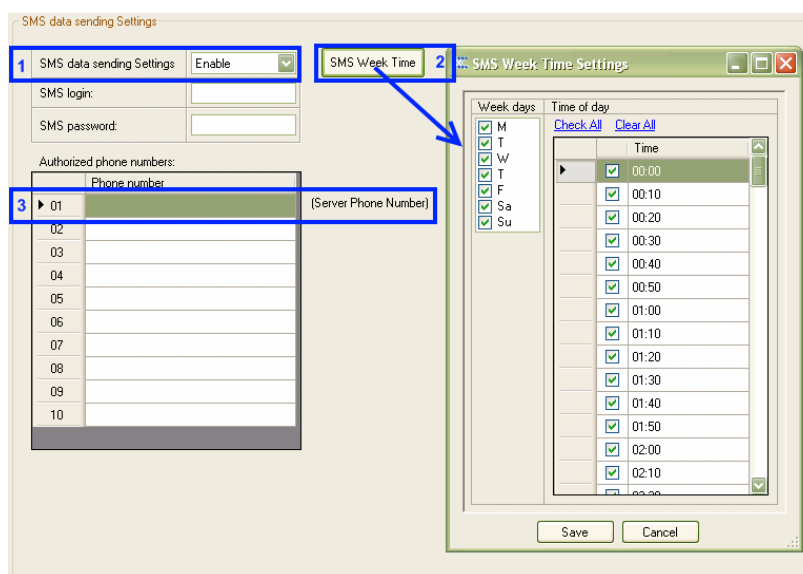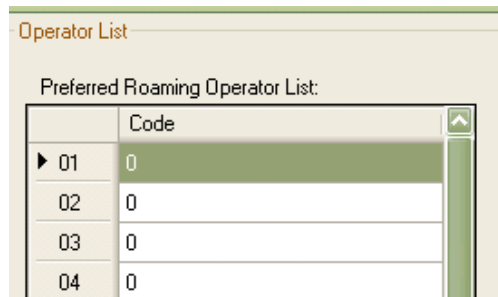
Figure 21. GSM->SMS Settings Configuration (2)

Using these settings FM5300 can send SMS with 24-coordinates in one SMS; it is used in areas where no GPRS coverage is available. Module collects data and sends to server binary SMS containing information about last 24 collected points. SMS sending schedule is set in SMS Week Time tab. 24-Coordinates SMS decoding is described in "FMXXXX Protocols" document.

6.3.2.2.3   Operator List

FM5300 is able to use GPRS with all operators but if at least one operator is entered in the list, FM5300 is allowed to connect to GPRS only while operating in listed operator's network. Also

operator list has influence on profile switching (see details in chapter 7) if Global parameter "Profile switching on event" is disabled .

Figure 22. FM53 Operator List Configuration

6.3.2.3 Features

6.3.2.3.1 Mode

FM5300 is able to collect records using three methods at the same time: time, distance and angle based data acquisition (chapter 8). Send and Save Parameters configuration is available in Features->Mode category (Figure 23):

- Min Period – time period change that initializes record save.
- Min Angle – angle change that initializes record save (only if vechicle is moving)..
- Min Distance – distance change that initializes record save (only if vechicle is moving).
- Send period – GPRS data sending to server period. Module makes attempts to send collected data to server every defined period. If it does not have enough records (depend on parameter Min. Saved Records described above), it tries again after defined time interval.
- GPRS Context Week Time tab – most GSM billing systems charge number of bytes (kilobytes) transmitted per session. During the session FM5300 makes connection and transmits data to a server. FM5300 tries to handle session as much as possible. Session can last hours, days, weeks or session can be closed after every connection in certain GSM networks – this depends on GSM network provider. GPRS Context Week Time defines session re-establish schedule if session was closed by network. New GPRS context is opened if time is 10 minutes till time checked in table. Therefore if all boxes are checked, FM5300 is able to open new connection anytime. At scheduled time match FM5300 checks for GPRS session activity. If GPRS session is alive, FM5300 sends data to server according to Send period parameter. If it is not, FM53 checks if it is able to re-establish the session.
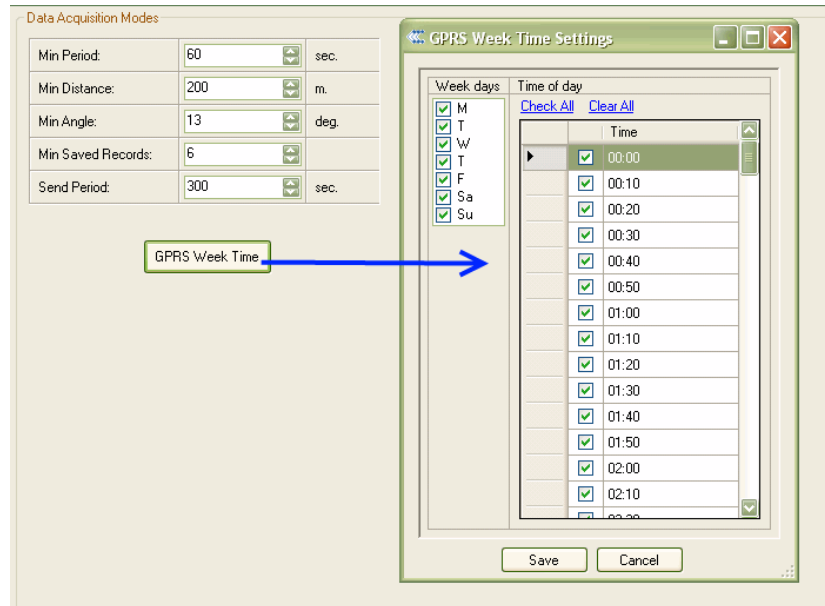
Figure 23. FM53 Features->Mode Configuration

6.3.2.3.2 Scenarios

In Scenarios window four different scenarios are available, two per each Digital Output (DOUT). Only one per digital output can be active at a same time, e.g. DOUT1 can have either ECO driving or Over Speeding enabled, DOUT2 can have either Authorized Driving or Immobilizer enabled.

Scenarios configurable parameters are shown in Figure 24. All values of these parameters are described in chapter 12.
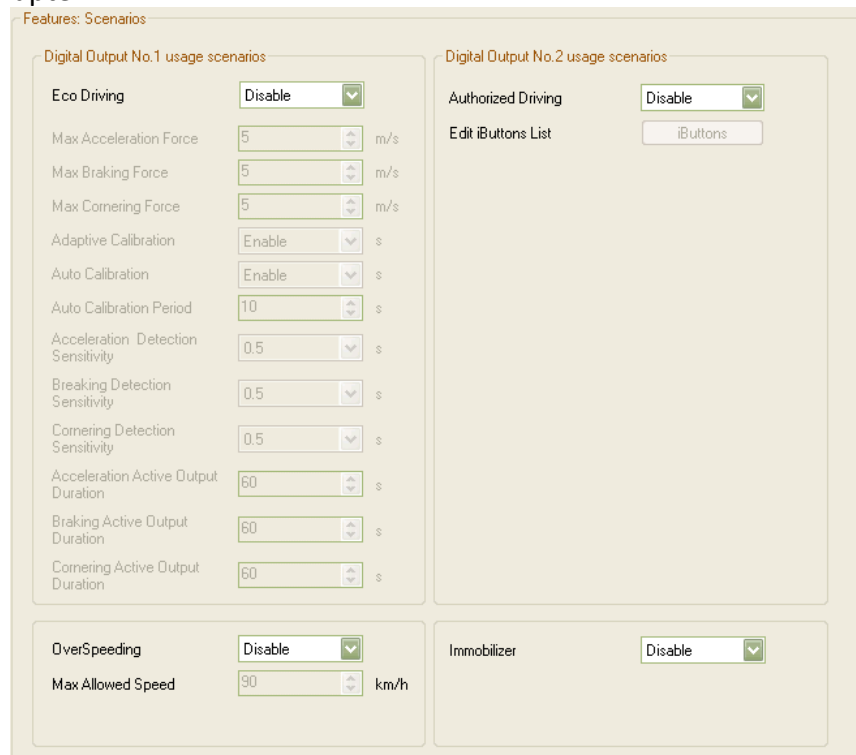
Figure 24. FM53 Features->Scenarios Configuration

6.3.2.3.3 Trip

Trip window offers user to configure Trip feature. If Trip is enabled configuration of parameters is available:
- Start Speed – speed, which is detected as minimum speed to indicate Trip start.
- Ignition Off Timeout – timeout to wait if ignition was off, to detect Trip stop.
- Continuous distance counting – Not or Continuous can be chosen. For this feature I/O Odometer must be enabled.

Figure 25. FM53 Features->Trip Configuration

If I/O Odometer is enabled and Continuous distance counting variable is set to Continuous, Trip distance is going to be counted continuously (from Trip start to Trip stop). This value is written to I/O Odometer value field. When Trip is over and next Trip begins, Odometer value is not reset to zero, it is counted continuously again.

If I/O Odometer is enabled and Continuous Distance Counting variable is set to Not, then distance is going to be counted only between every record made. This value is written to I/O Odometer value field and reset to zero every new record until Trip stops. If later all Odometer values are summed up manually user gets distance driven over whole Trip period.

6.3.2.3.4 Geofencing

6.3.2.3.4.1   Geofencing settings

FM5300 has 20 configurable Geofence zones and it can generate event when defined Geofence zone border has been crossed.

Figure 26. FM53 Features->Geofencing Configuration (1)

Configuration of the parameters is available in Features->Geofencing (Figure 26)

- Frame border – frame border is an additional border around Geofence zone. It is additional area around defined zone used to prevent false event recording when object stops on the border of the area and because of GPS errors some records are made inside area and some – outside. Event is generated only when both borders are crossed. See figure for details: track 1 is considered to enter the area while track 2 does not.
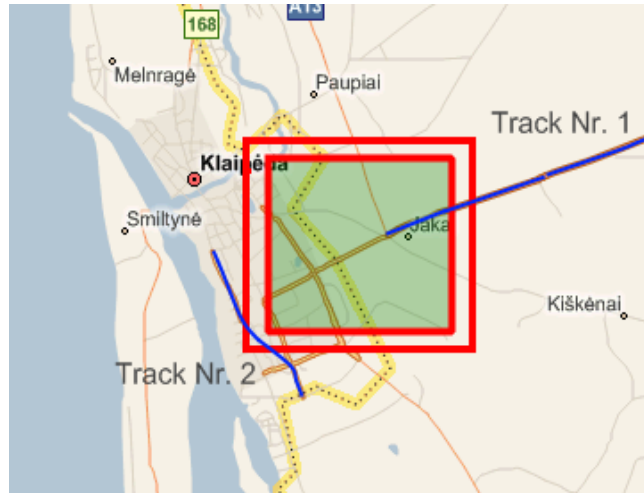
Figure 27. Geofence border

- Shape – can be rectangular or circle
- Priority – priority of Geofence event: low, high or panic. These levels define priority of event information sending to server. See I/O element description for more details about priorities.
- Generate event (On entrance, On exit, On Both) – choose when record will be generated;
- X1 – geofence zone left bottom corner X coordinate;
- Y1 – geofence zone left bottom corner Y coordinate;
- X2 or R – geofence zone upper right corner X coordinate (radius of circle when Circular zone used);
- Y2 – geofence zone upper right corner Y coordinate;

6.3.2.3.4.2   AutoGeofencing settings

"AutoGeofence| – the last known position after movement = off. If your car's being taken away – you can be notified. The shape and size of the geofence zones are parameters. Possibility to state whether entering in or out of the geofence triggers an asynchronous message."
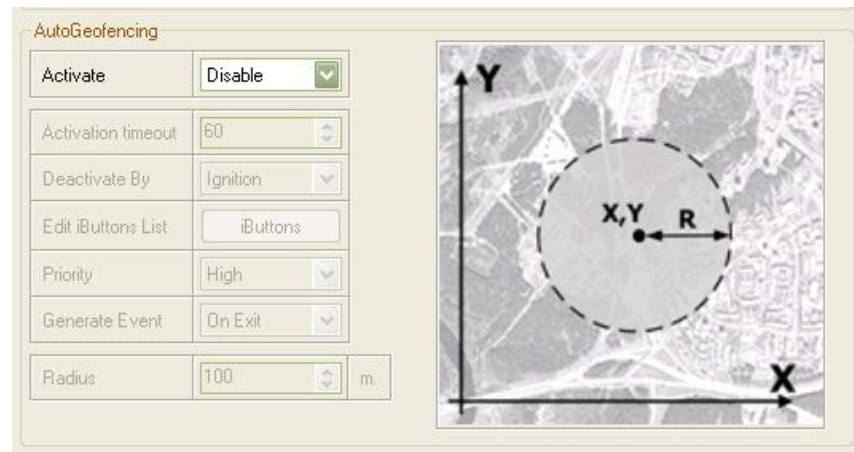
Figure 28. FM53 Features->Geofencing Configuration (2)

Auto Geofencing option can be configured by following parameters (Figure 28):
- Activate – Enable or Disable Autogeofence functionality
- Activation TMO – Time period before Geofence is activated after vehicle stops.
- Deactivate By :
  - Ignition – If ignition becomes high it will drop AutoGeofenze Zone
  - iButton – if iButton is attached it will drop AutoGeofence Zone
- Edit iButton List – if list is not empty attached iButton is tested against a iButton list, if match is found AutoGeofence zone is dropped.
- Priority – Priority of generated event, which will be applied to saved record.
- Generate Event:
  - Enter Event – Event generation on Geofence entrance.
  - Exit Event – Event generation on Geofence exit.
  - On Both - Event generation on Geofence entrance Or exit.

Auto Geofencing does not require entering coordinates, instead it requires GPS visibility. If vehicle stopped and activation timeout is passed, Auto Geofence will be created around vehicle last position by set Radius value. Auto Geofence event generation works the same as Geofencing mentioned above.

6.3.2.3.5   iButton List
iButton list is used to enter authorized iButton ID codes, which are used to authenticate driver in Authorized driving and Auto Geofencing options.
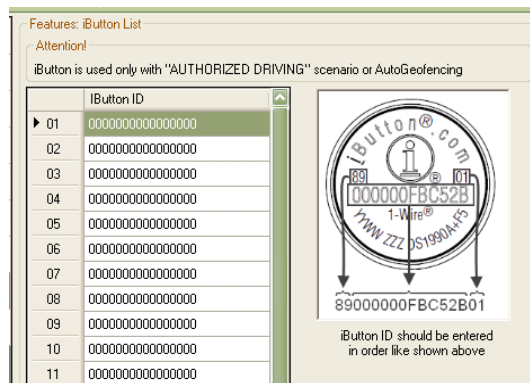
Figure 29. Features->iButton Configuration

iButton value must be entered as it is written on it.

6.3.2.4 I/O

If all I/O elements are disabled AVL packet comes with GPS information only. After enabling I/O element(s) AVL packet in couple with GPS information contains current value(s) of enabled I/O element.

6.3.2.4.1 FM5300 available I/O list

Table 9 PERMANENT I/O elements list description

Permanent I/O elements (are always sent (with every record) to server if enabled)			
Property ID in AVL packet	Property Name	Bytes	Description
1	Digital Input Status 1	1	Logic: 0 / 1
2	Digital Input Status 2	1	Logic: 0 / 1
3	Digital Input Status 3	1	Logic: 0 / 1
4	Digital Input Status 4	1	Logic: 0 / 1
9	Analog Input 1	2	Voltage: mV, 0 – 30 V
10	Analog Input 2	2	Voltage: mV, 0 – 30 V
11	Analog Input 3	2	Voltage: mV, 0 – 30 V
19	Analog Input 4	2	Voltage: mV, 0 – 30 V
21	GSM signal level	1	Value in scale 1 – 5
22	Actual profile	1	Value in scale 1 – 4
24	Speedometer	2	Value in km/h, 0 – xxx km/h
50	Digital Output Status 3	1	Logic: 0 / 1
51	Digital Output Status 4	1	Logic: 0 / 1
66	External Power Voltage	2	Voltage: mV, 0 – 30 V
67	Internal Battery Voltage	2	Voltage: mV
68	Internal Battery Current	2	Voltage: mA
70	PCB Temperature	4	10 * Degrees (°C)
71	GNSS status	1	0-off/ 1-restarting/ 2-ready(on, no fix)/ 3-working/ 4-sleep
72	Dallas Temperature 1	4	10 * Degrees (°C), -55 - +115, if 3000 – Dallas error
73	Dallas Temperature 2	4	10 * Degrees (°C), -55 - +115, if 3000 – Dallas error
74	Dallas Temperature 3	4	10 * Degrees (°C), -55 - +115, if 3000 – Dallas error
76	Fuel Counter	4	Difference of generated impulses on two signal lines

Permanent I/O elements (are always sent (with every record) to server if enabled)			
Property ID in AVL packet	Property Name	Bytes	Description
78	iButton Input	8	iButton ID number
179	Digital output 1 state	1	Logic: 0 / 1
180	Digital output 2 state	1	Logic: 0 / 1
181	PDOP	2	Probability * 10; 0-500
182	HDOP	2	Probability * 10; 0-500
199	Odometer	4	Distance between two records: m
200	Deep Sleep	1	0 – not deep sleep mode, 1 – deep sleep mode
205	Cell ID	2	GSM base station ID
206	Area Code	2	Location Area code (LAC), it depends on GSM operator. It provides unique number which assigned to a set of base GSM stations. Max value: 65536
240	Movement	1	0 – not moving, 1 – moving.
241	Current Operator Code	4	Currently used GSM Operator code

Table 10 EVENTUAL I/O elements list description

Eventual IO elements (generated and send record to server only if appropriate conditions are met)			
Property ID in AVL packet	Property Name	Bytes	Description
140	CAN 0	Varying[4]	ID Specific data
141	CAN 1	Varying	ID Specific data
142	CAN 2	Varying	ID Specific data
143	CAN 3	Varying	ID Specific data
144	CAN 4	Varying	ID Specific data
145	CAN 5	Varying	ID Specific data
146	CAN 6	Varying	ID Specific data
147	CAN 7	Varying	ID Specific data
148	CAN 8	Varying	ID Specific data
149	CAN 9	Varying	ID Specific data
150	CAN 10	Varying	ID Specific data
151	CAN 11	Varying	ID Specific data
152	CAN 12	Varying	ID Specific data
153	CAN 13	Varying	ID Specific data
150	CAN 10	Varying	ID Specific data
155	Geofence zone 01	1	Event: 0 – target left zone, 1 – target entered zone
156	Geofence zone 02	1	Event: 0 – target left zone, 1 – target entered zone
157	Geofence zone 03	1	Event: 0 – target left zone, 1 – target entered zone
158	Geofence zone 04	1	Event: 0 – target left zone, 1 – target entered zone
159	Geofence zone 05	1	Event: 0 – target left zone, 1 – target entered zone
160	Geofence zone 06	1	Event: 0 – target left zone, 1 – target entered zone

[4] CAN property length can vary depending on filter settings. Data can be sent as 1, 2, 4 or 8 byte property.

Eventual IO elements (generated and send record to server only if appropriate conditions are met)			
Property ID in AVL packet	Property Name	Bytes	Description
161	Geofence zone 07	1	Event: 0 – target left zone, 1 – target entered zone
162	Geofence zone 08	1	Event: 0 – target left zone, 1 – target entered zone
163	Geofence zone 09	1	Event: 0 – target left zone, 1 – target entered zone
164	Geofence zone 10	1	Event: 0 – target left zone, 1 – target entered zone
165	Geofence zone 11	1	Event: 0 – target left zone, 1 – target entered zone
166	Geofence zone 12	1	Event: 0 – target left zone, 1 – target entered zone
167	Geofence zone 13	1	Event: 0 – target left zone, 1 – target entered zone
168	Geofence zone 14	1	Event: 0 – target left zone, 1 – target entered zone
169	Geofence zone 15	1	Event: 0 – target left zone, 1 – target entered zone
170	Geofence zone 16	1	Event: 0 – target left zone, 1 – target entered zone
171	Geofence zone 17	1	Event: 0 – target left zone, 1 – target entered zone
172	Geofence zone 18	1	Event: 0 – target left zone, 1 – target entered zone
173	Geofence zone 19	1	Event: 0 – target left zone, 1 – target entered zone
174	Geofence zone 20	1	Event: 0 – target left zone, 1 – target entered zone
175	Auto Geofence	1	Event: 0 – target left zone, 1 – target entered zone
250	Trip	1	1 – trip start, 0 – trip stop
251	Immobilizer	1	1 – iButton connected
252	Authorized driving	1	1 – authorized iButton connected
253	ECO driving type	1	1 – harsh acceleration, 2 – harsh braking, 3 - harsh cornering
254	ECO driving value	2	Depending on green driving type: if harsh acceleration, braking and cornering – $g*10$ m/s^2
255	Over Speeding	2	At over speeding start km/h, at over speeding end km/h

There are two types of operations with Permanent I/O elements: simple monitoring and event generating. Monitoring method is used when current I/O information needed with regular GPS coordinates. Event generating method is used when additional AVL packet is needed when current value of I/O exceeds predefined High and Low levels. I/O settings allow defining I/O event criteria.

6.3.2.4.2   I/O configuring

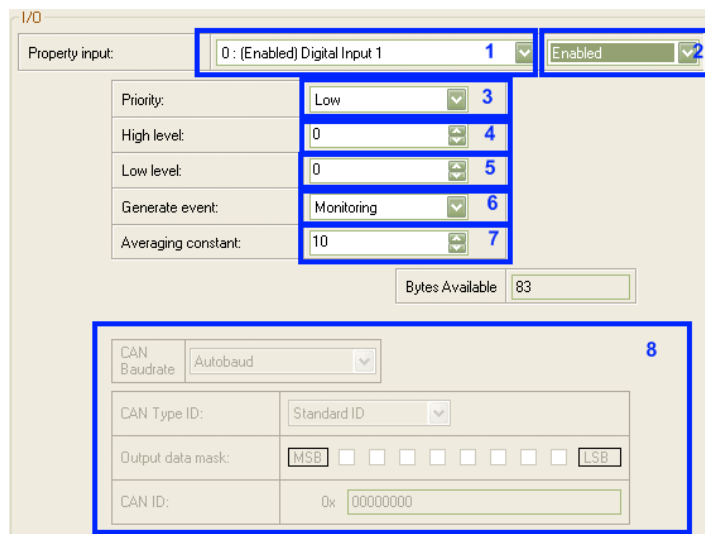I/O configuration has 8 main parts (Figure 30):

Figure 30. FM53 I/O Configuration (1)

Table 11 I/O Configuration window description

Pos. Nr.	DESCRIPTION
1.	Property inputs list
2.	Enable/Disable chosen property input - allows enabling I/O element so it is added to the data packet and is sent to the server. By default, all I/O elements are disabled and FM5300 records only GPS part. It is also possible to set CAN message instead of any I/O element – this way CAN element will be sent to the server instead of chosen element. See CAN description below for more details (…).
3.	Priority - AVL packet priority. There are Low, High, Panic, SW21, SW22, SW23 and SW24 priorities. Regular packets are sent as Low priority records. When low priority event is triggered, FM5300 makes additional record with indication that the reason for that was IO element change. When High priority is selected, module makes additional record with high priority flag and sends event packet immediately to the server. First it tries it send using GPRS, if GPRS fails, it sends AVL packet using SMS mode if SMS is enabled in SMS settings. Panic priority event forces module to send AVL packet to server and switch operating profile to Profile 4. (for details see chapter 7). SW2X priorities switch profiles on event.
4.	High Level - define I/O value range. If I/O value enters or exits this range, FM5300 generates event.
5.	Low Level – define I/O value range. If I/O value enters or exits this range, FM5300 generates event.
6.	Generate event – defines when to generate event. When value enters defined range, exits it or both enters and exits.
7.	Averaging Constant – it is an I/O event delay parameter. In some applications there is no need to generate events on every I/O range enter/exit immediately. Sometimes it is necessary to wait some time interval before event generating to be ensuring that current event is not short time event. Averaging constant allows setting I/O event delay (averaging). If I/O value is entering or leaving predefined range, it must have same value for Averaging constant time. One unit of averaging constant value equals 20 milliseconds.

Pos. Nr.	DESCRIPTION
	Selected data source value input averaging constant are calculated by following formula: $$VAL^{Mean} = \frac{VAL^{Mean-1} \times (CONST - 1) + REALVAL}{CONST}$$ Where: VAL^{Mean} – Value calculated during actual cycle[5]; VAL^{Mean-1} – Value calculated during previous cycle; CONST – averaging constant; REALVALUE – Real value detected on digital input.
8.	CAN - Controller Area Network (CAN or CAN-bus) is a computer network protocol and bus standard designed to allow microcontrollers and devices to communicate with each other and without a host computer (…)

There are only 14 IO parameters that could use Averaging Constant:
Digital Inputs (1-4); Analog Inputs (1-4); Battery Voltage; Battery Current; External Voltage ; PDOP; HDOP; Speedometer.
I/O parameters: "Current Profile", "Digital Output 1..4", "GMSS Status", "Movement", "Active GSM Operator", "iButton ID", "GSM Signal", "Deep Sleep", "Cell ID", "Area Code", "PCB Temperature", "Temperature Sensor 0..2", "Fuel Counter" cannot use Averaging constant functionality.

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[5] One cycle equal to 20 ms.

7 PROFILE SWITCHING

FM5300 has 4 profiles saved in Flash memory of the module. Every profile has a list of parameters, which enables FM5300 to operate in different modes while using different profiles. The easiest way to understand what is profile is to compare it to a list of instructions that are written for different cases. You are allowed to setup up to 4 different module behaviours. Global parameters contain settings that are common for al 4 profiles. This means that if you set FM5300 to call to predefined number, you will be able to call it while using any profile. Basic scheme of Global parameters and profiles is shown below. According to the scheme, every profile has a list of parameters. Global parameters are common for all profiles. (Figure 31)
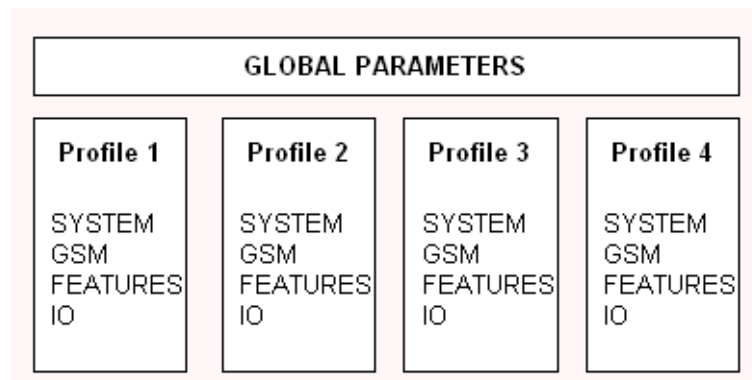
Figure 31. FM5300 profile structure

Switching between profiles (changing behaviour) can be performed by Profile switch depending on GSM operator code (mostly used for roaming applications), or by Profile switch depending on I/O event (on I/O value changing).

Profile 3 is default profile for FM5300. It is always loaded on very first start-up and further profile switching is proceeded after operator scan or I/O element changes (although device remembers which profile it used after that).

7.1 Depending on GSM Operator Profile Switching

GSM Operator code profile switching is mostly used in roaming applications, when the purpose is to have information from module both from Home and Roaming operator network for reasonable price. This method allows you to define different module behaviour in Home network, Roaming network and unknown operator areas. See figure below for details.

Profile 1 is configured for home network. Data acquisition and send intervals are quite frequent here. To make profile use effective, it is wise to set more optimized parameters in roaming profile (Profile 2) – this usually includes larger coordinate recording intervals, packets with greater number of coordinates sending, and in some cases GPRS context available only for certain time interval. Profile 3 can either contain operator codes (rarely used) or have empty list.

Profile 4 is not used (profile 4 can only be used when FM5300 encounters a 'panic' priority event (see 7.2 chapter)).

In the example (Figure 32) FM5300 connects to operator with code 24702. It checks profile 1 operator list, but there is only one operator code entered which does not mach. Then it checks profile 2 list. This code is entered there, so FM5300 switches to profile 2.
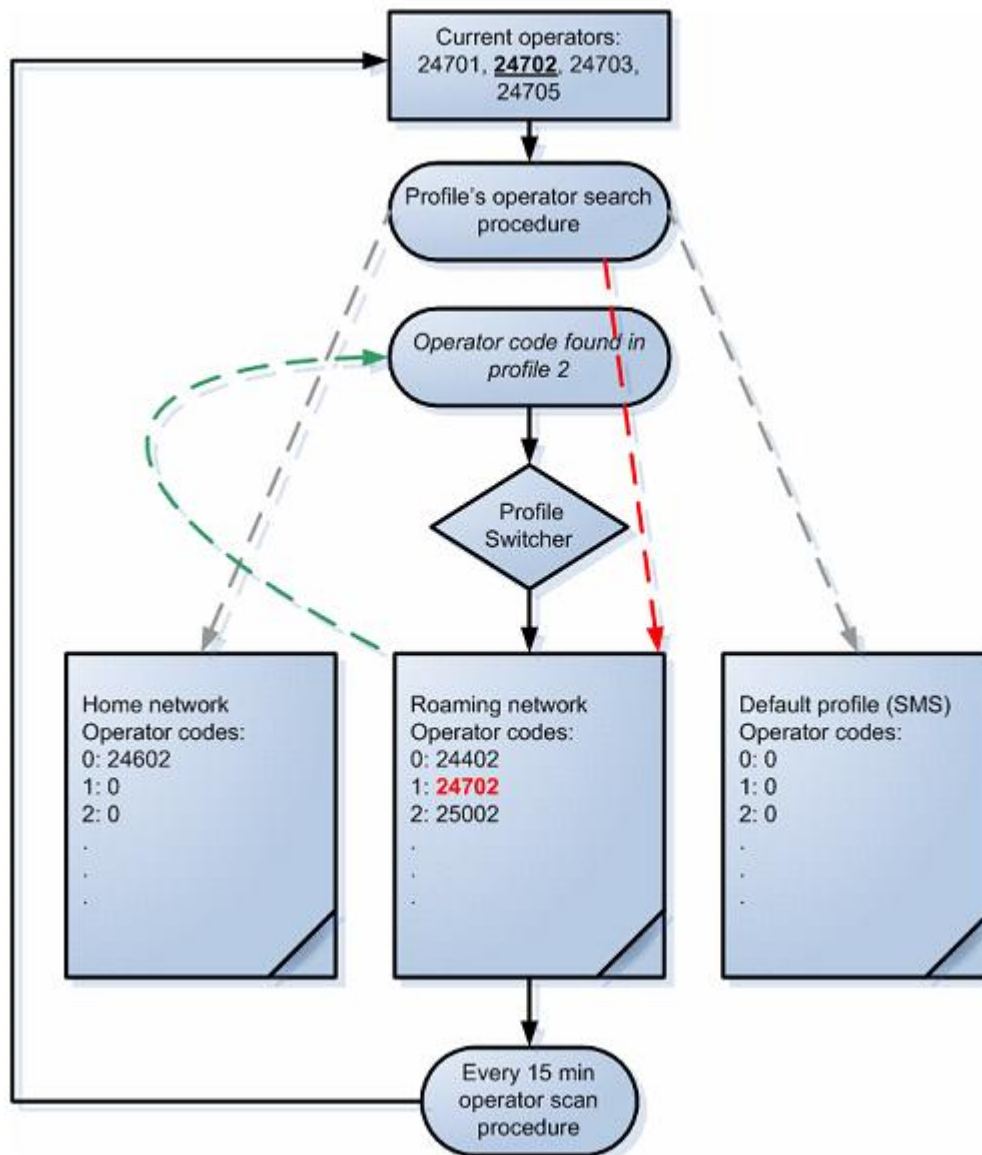
Figure 32. GSM Operator code profile switching (…)

If there are no operator codes entered in all profiles after operator search task FM5300 will check all 3 profiles and won't find any operators in a list. In such case FM5300 will switch to profile 3. Note that before switching to profile 3 device detaches GPRS session.

Operator search is performed every 15 minutes. If no operators are entered in any profile it can have influence on GPRS sessions. IF GPRS sessions are attaching/detaching every 15 minutes it means configuration of FM5300 is performed incorrectly.

7.2 Depending on I/O Event Profile Switching

Another profile switch method is based on I/O event. Events happen when the value of enabled I/O intersects thresholds (enter, exit, on both) predefined by High and Low level thresholds. SW21, SW22, SW23, SW24 stand for "Switch to profile No. X" – after event happens, FM5300 switches to defined profile. Using profile switching you can create smart applications. SW2X actions can be performed only if "Profile change on event" is enabled in Global parameters. Pictures below illustrate profile switching depending on digital events:
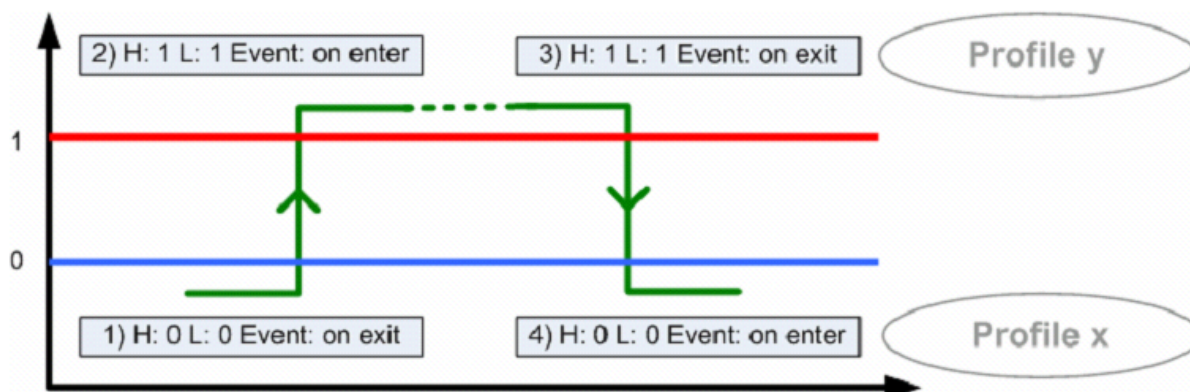
Figure 33. Digital input event criteria

7.2.1   Example #1

Configuration of Profile1 to switch to Profile2 on DIN1 value change from 0 to 1:
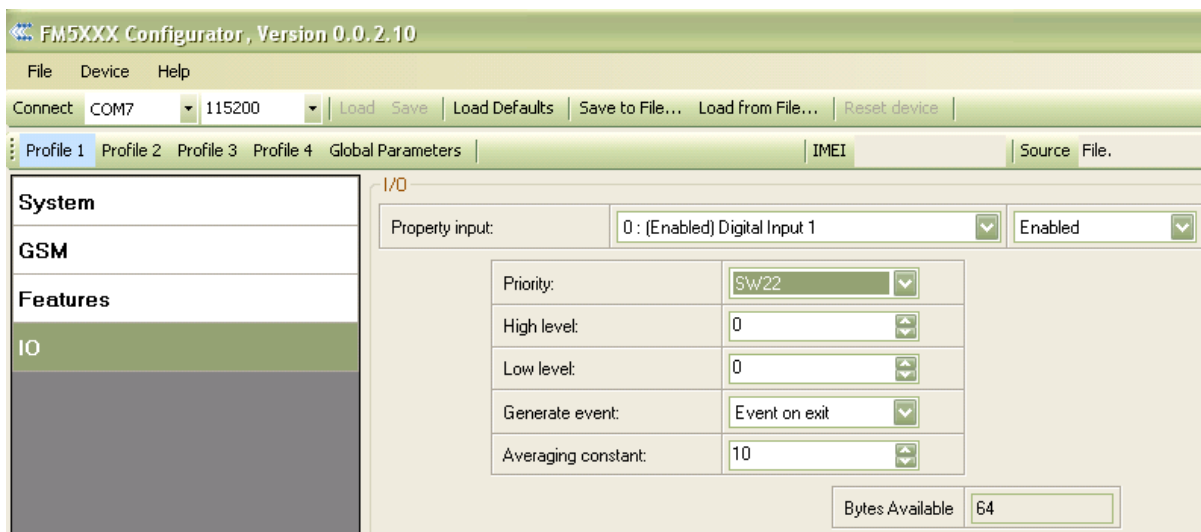
Figure 34. Switch to profile on event (1)

7.2.2   Example #2

Configuration of Profile2 to switch to Profile1 on DIN1 value change from 1 to 0:
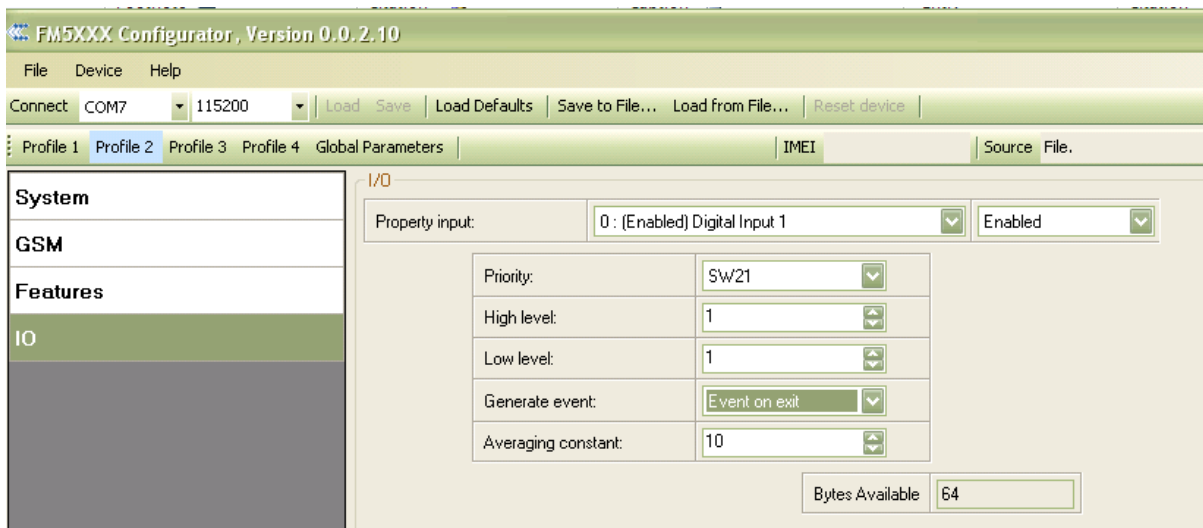
Figure 35. Switch to profile on event (2)

8 DATA ACQUISITION

Data can be acquired using GPS or IO elements. GPS data is for basic vehicle tracking, data acquisition by IO elements gives more specific information.

8.1 GPS data acquisition

There are three ways of GPS data acquisition which are configured in *Features > sMode* menu (Figure 36).

Device checks angle, distance and time differences with last saved record. If differences are greater than configured record are generated. Checking sequence: First is checked angle then distance and the last - time differences.
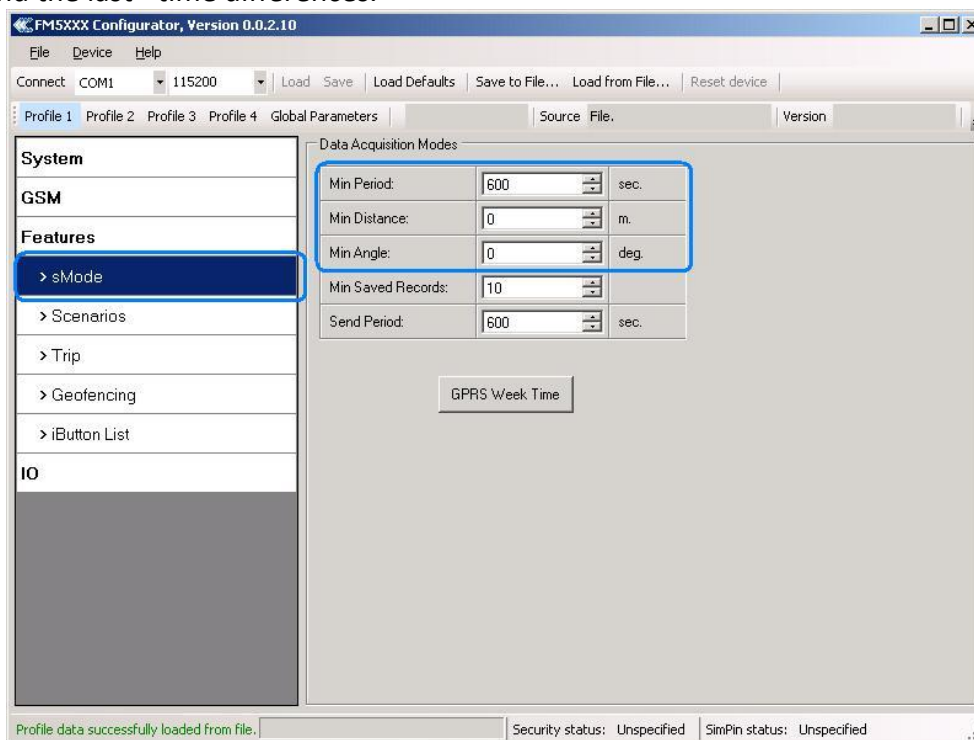
Figure 36 GPS acquisition configuration window

Actual configuration parameters are marked in blue.

8.1.1 Min. Period

Time based data acquiring (Figure 37) – records are being acquired every time when defined interval of time passes. Entering zero means that data will be recorded as fast as possible (every second). This method is suit best for basic position update.
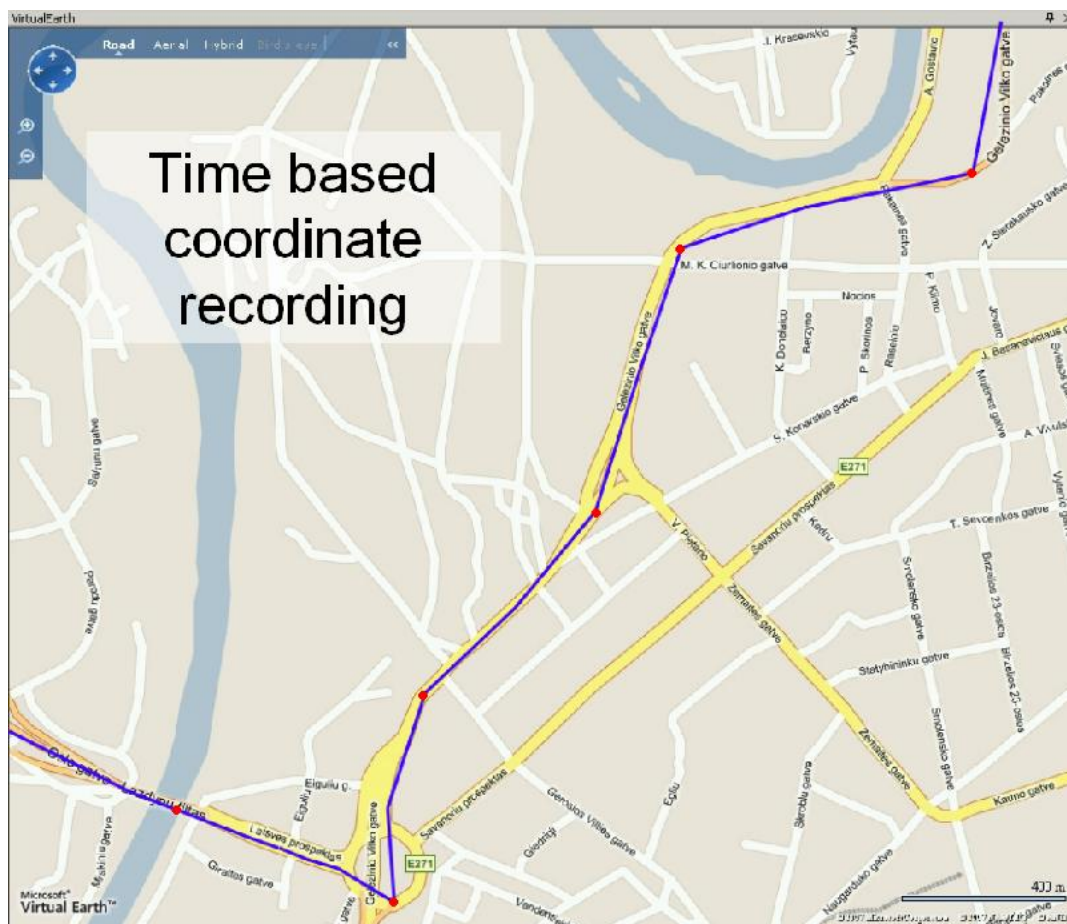
Figure 37 Time based tracking

8.1.2 Min. Distance

Distance based data acquiring (Figure 38) – records are being acquired when the distance between previous coordinate and current position is greater than defined parameter value. Entering zero means that data won't be recorded. This method is suit for non-urban territories where moving trajectory is straight.
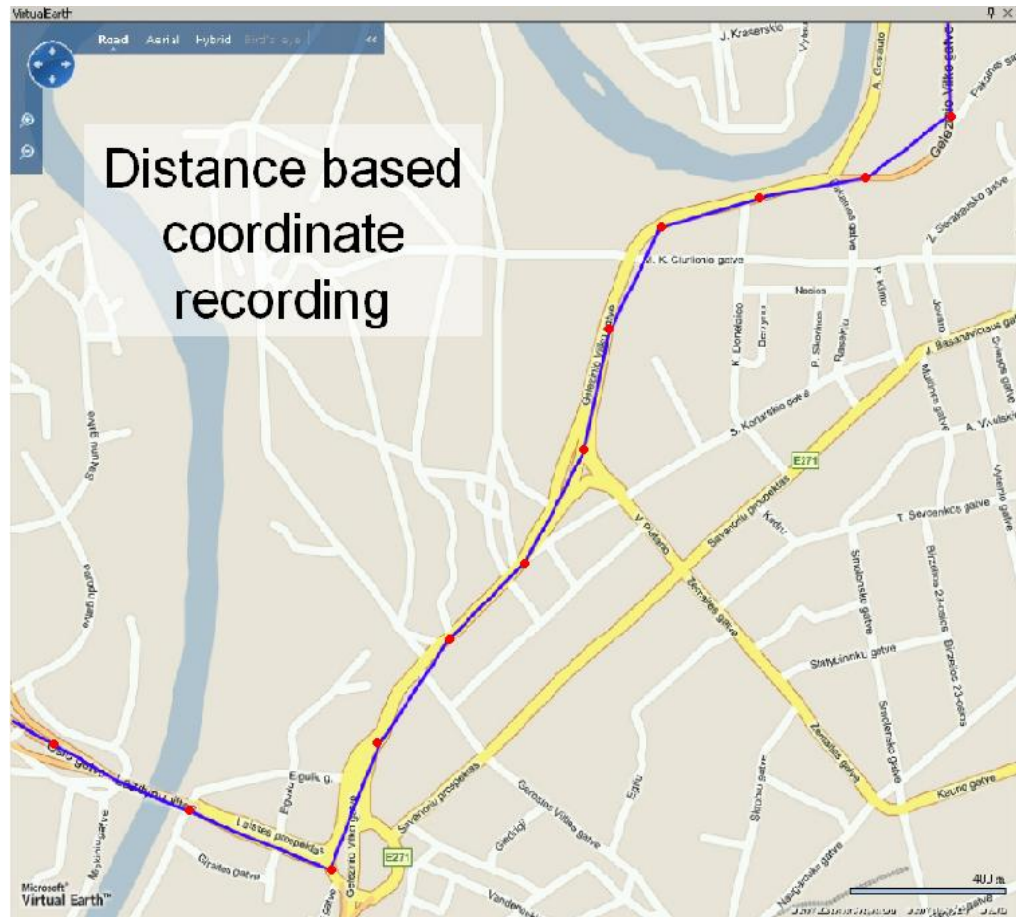
Figure 38 Distance based tracking

8.1.3 Min. Angle

Angle based data acquiring (Figure 39) – records are being acquired when angle difference between last recorded coordinate and current position is greater than defined value. Entering zero disables data acquisition depending on angle. This method is suit for urban territories. Note that record generation by angle is performed if vehicle is moving at least 6 km/h.
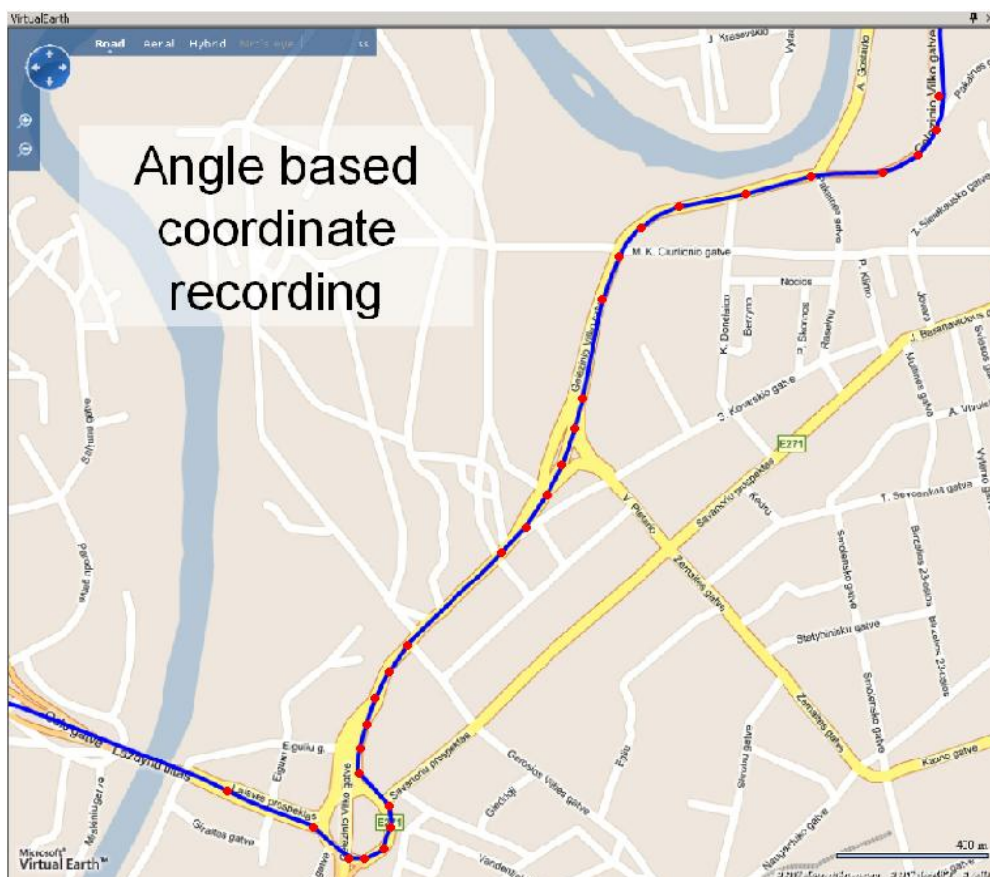
Figure 39 Angle based tracking

8.2 I/O data acquisition

Data also can be acquired using input output elements (it's change) . All base elements are declared in Table 9 PERMANENT I/O elements list description *and in* Table 10 EVENTUAL I/O elements list description

8.2.1 Configuration

Data acquisition by I/O elements can be configured selected IO menu in configurator (refer to chapter 6.3.2.4.2).

Priority: Low – as a regular data; High – generated record are sent immediately to server; Panic - generated record are sent immediately to server and simultaneously the same record as SMS message;

High Level: High range of value input;

Low Level: Low Range of value input;
Averaging constant: (see detailed description in chapter 6.3.2.4.2)

8.2.2   Event generation

There are five record event generation types examples (I/O speed is taken as I/O value example), please refer to Figures below.

Figure 40 Event On Zone exit

Figure 41 Event On Zone entrance

Figure 42 vent On both

Figure 43 Monitoring

Figure 44 Evenet on Hysteresis
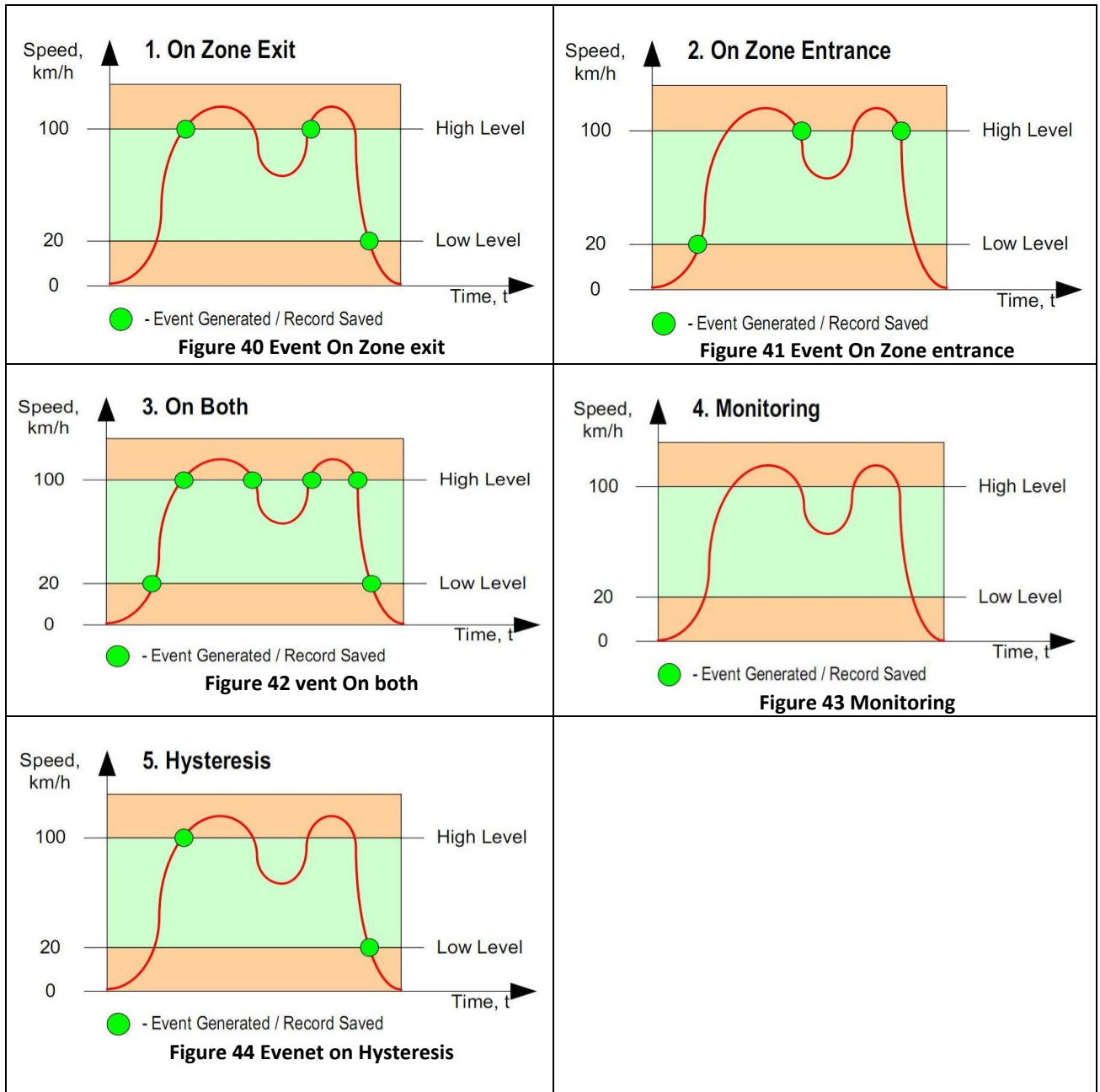
Event on Zone Entrance: record is generated then actual source value input is between High and Low level ranges which are set in configuration;

Event on Zone Exit: record is generated then actual source value input increases and become higher than High level and Low level values;

Event on Both: record is generated then actual source value input increases/decreases and becomes higher/less than high and low level declared values;

Monitoring: no event at all; I/O values are recorded only when other trigger will work (GPS acquisition or other I/O trigger)

Hysteresis: record is generated then actual source value input becomes higher than High level value, and decreasing becomes less than low level value

Event on Change: record is generated on every source value change.

9   DATA SENDING – GPRS

9.1   DATA PROTOCOLS

9.1.1   AVL data packet

AVL packet (Table 12) is used to encapsulate AVL data and send it to server.

Table 12 AVL Data packet

Constant Prefix Field		Data Field (5.1.2 subsection)	Cyclic Redundancy Check
Four Zeros	Data Length Field	Data	CRC-16
Four Zeros	Data Length Field	Data	CRC-16
4 Bytes	*4 Bytes*	*…*	*4 Bytes*

- *Four zeros* – four zero bytes: `0x00 0x00 0x00 0x00`;
- *Data length* – number of bytes in data field;
- *Data* – any AVL data array;
- *CRC* – 16 bit CRC value of data (Integer). Polynomial 0xA001.

9.1.2   AVL Data Array

Because the smallest information amount that can be written is one bit, there can be some bits left unused when result is byte array. Any unused bits should be left blank.

Table 13 AVL Data Array structure

Codec ID	Number of Data	Data (5.1.3 subsection)	Number of Data
1 Byte	*1 Byte*	*…*	*1 Byte*

- *Codec ID* – packet ID: `0x08`;

- *Number of Data* – number of encoded data (number of records): `variable`;

- *Data* – encoded data: `variable`.

9.1.3 AVL data

Table 14 AVL Data structure

Timestamp	Priority (5.1.4 subsection)	GPS Element (5.1.5 subsection)	I/O Element (5.1.6 subsection)
8 Bytes	*1 Byte*	*15 Bytes*	*...*

- *Timestamp* – difference, in milliseconds, between the current time and midnight, January 1, 1970 UTC.

9.1.4 Priority

Table 15 Priority field description

Value	Priority
0	Low
1	High
2	Panic
3	Security

9.1.5 GPS Element

Table 16 GPS element structure

Longitude	Latitude	Altitude	Angle	Satellites	Speed
4 Bytes	*4 Bytes*	*2 Bytes*	*2 Bytes*	*1 Byte*	*2 Bytes*

- *Longitude*[6]: X;
- *Latitude*[4]: Y;
- *Altitude* – in meters above sea level[4];
- *Angle* – in degrees, 0 is north, increasing clock-wise [4];
- *Satellites* – number of visible satellites[4];
- *Speed* – speed in km/h. 0x0000 if GPS data is invalid[7];

Longitude and latitude are integer values built from degrees, minutes, seconds and milliseconds by formula.

$$\left(d + \frac{m}{60} + \frac{s + \frac{ms}{1000}}{3600}\right) \cdot p$$

where, d – degrees, m – minutes, s – seconds, ms – milliseconds, p – precision (10000000)

---

[6] If record is without valid coordinates – (there were no GPS fix in the moment of data acquisition) – Longitude, Latitude and Altitude values are last valid fix, and Angle, Satellites and Speed are 0.

[7] If record is without valid coordinates – (there were no GPS fix in the moment of data acquisition) – Longitude, Latitude and Altitude values are last valid fix, and Angle, Satellites and Speed are 0.

If longitude is in west or latitude in south, multiply result by –1. To determine if the coordinate is negative, convert it to binary format and check the very first bit. If it is 0, coordinate is positive, if it is 1, coordinate is negative.

Example:

- *Received value*: `0x20 0x9c 0xca 0x80`;
- *Converted to binary format*: **0**0100000 10011100 11001010 10000000 first bit (bold) is 0, which means coordinate is positive;
- *Converted to decimal format*: `547146368`;
- *For more information see two's compliment arithmetics*.

9.1.6 I/O Element

Table 17 I/O element structure

Event IO ID	N of **Total** IO	N1 of **One Byte**	**1'st** IO ID	**1'st** IO Value	...	**N1'th** IO ID	**N1'th** IO Value	N2 of **Two Bytes**	**1'st** IO ID	**1'st** IO Value	...	**N2'th** IO ID	**N2'th** IO Value	N4 of **Four Bytes**	**1'st** IO ID	**1'st** IO Value	...	**N4'th** IO ID	**N4'th** IO Value	N8 of **Eight Bytes**	**1'st** IO ID	**1'st** IO Value	...	**N8'th** IO ID	**N8'th** IO Value
1 Byte	*1 Byte*	*1 Byte*	*1 Byte*	*1 Byte*		*1 Byte*	*1 Byte*	*1 Byte*	*1 Byte*	*2 Bytes*		*1 Byte*	*2 Bytes*	*1 Byte*	*1 Byte*	*4 Bytes*		*1 Byte*	*4 Bytes*	*1 Byte*	*1 Byte*	*8 Bytes*		*1 Byte*	*8 Bytes*

- *Event IO ID* – if data is acquired on event – this field defines which IO property has changed and generated an event. If data cause is not event – the value is 0;
- *N* – total number of properties coming with record (N=N1+N2+N4+N8);
- *N1* – number of properties, which length is 1 byte;
- *N2* – number of properties, which length is 2 bytes;
- *N4* – number of properties, which length is 4 bytes;
- *N8* – number of properties, which length is 8 bytes.

9.1.6.1 Example

Received data:

```
080400000113fc208dff000f14f650209cca80006f00d60400040004030101150
316030001460000015d0000000113fc17610b000f14ffe0209cc580006e00c005
0001000403010115031601000146000015e0000000113fc284945000f150f002
09cd200009501080400000004030101150016030001460000015d0000000113fc
267c5b000f150a50209cccc000930068040000000040301011500160300014600
0015b0004
```

- **08** – Codec ID;
  - ○ **04**- Number of Data (4 records);
    - ▪ **1'st record data;**
      - − **00000113fc208dff** – Timestamp in milliseconds (1185345998335 → 1185345998,335 in Unix Timestamp = 25 Jul 2007 06:46:38 UTC);
      - − **00** – Priority;
    - ▪ **GPS Element;**
      - − **0f14f650** – Longitude 253032016 = 25,3032016º N;
      - − **209cca80** – Latitude 547146368 = 54,7146368 º E;
      - − **006f** – Altitude 111 meters;
      - − **00d6** – Angle 214º;
      - − **04** – 4 Visible sattelites;
      - − **0004** – 4 km/h speed;
    - ▪ **IO Element;**
      - − **00** – IO element ID of Event generated (in this case when 00 – data generated not on event);
      - − **04** – 4 IO elements in record;
      - − **03** – 3 IO elements, which length is 1 Byte;
      - − **01** – IO element ID = 01;
      - − **01** – 1'st IO element's value = 1;
      - − **15** – IO element ID = 21;
      - − **03** – 21'st IO element's value = 3 ;
      - − **16** – IO element ID = 22;
      - − **03** – 22'nd IO element's value = 3;
      - − **00** – 0 IO elements, which value length is 2 Bytes;
      - − **01** – 1 IO element, which value length is 4 Bytes;
      - − **46** – IO element ID = 70;
      - − **0000015d** – 70'th IO element's value = 349;
      - − **00** – 0 IO elements, which value length is 8 Bytes;
    - ▪ **2'nd record data;**
      - − 00000113fc17610b000f14ffe0209cc580006e00c005000100040301 01150316010001460000015e00;
    - ▪ **3'd record data;**
      - − 00000113fc284945000f150f00209cd200009501080400000004030 101150016030001460000015d00;
    - ▪ **4'th record data;**
      - − 00000113fc267c5b000f150a50209cccc00093006804000000040301 01150016030001460000015b00;
  - ○ **04**- Number of Data (4 records).

9.2   Sending Data Over TCP

9.2.1   Communication with server

First when module connects to server, module sends its IMEI. IMEI is sent the same way as encoding barcode. First comes short identifying number of bytes written and then goes IMEI as text (bytes).

For example IMEI 123456789012345 would be sent as:

- 000F313233343536373839303132333435.

After receiving IMEI, server should determine if it would accept data from this module. If yes server will reply to module 01 if not 00. Note that confirmation should be sent as binary packet.

Then module starts to send first AVL data packets. After server receives packets and parses its, server must report to module number of data received as integer (four bytes).

If sent data number and reported by server doesn't match module closes connection with server.

Example:

1. Module connects to server and sends IMEI;
    FM → 000F313233343536373839303132333435
2. Server accepts the module;
    01 ← Server
3. Module sends data packet:
    FM → 00000000000000FE0802...(data elements)...0200008612
    - 00000000 – four zero bytes;
    - 000000FE – data length hexadecimal, converted to decimal: 254;
    - 08 – codec ID;
    - 02 – number of data (encoded using continuous bit stream. Last byte padded to align to byte boundary);
    - ...(data elements)... – AVL data array;
    - 02 – number of data (encoded using continuous bit stream. Last byte padded to align to byte boundary);
    - 00008612 – CRC;
4. Server acknowledges data reception (2 data elements):
    00000002 ← Server

9.3   Sending Data Over UDP

9.3.1   UDP Channel Protocol

UDP channel is a transport layer protocol above UDP/IP to add reliability to plain UDP/IP using acknowledgment packets. The packet structure is as follows:

5.7 table. UDP packet structure

Constant Prefix Field			Data Field (5.3.1 subsection)
Data Length Field	**Packet ID**	**Packet Type**	**Data**
2 Bytes	*2 Bytes*	*1 Byte*	*...*

- *Data Length Field* – Packet length (excluding this field) in big endian byte order;
- *Packet ID* – Packet id unique for this channel;
- *Packet Type* – Type of this packet;
- *Data* – encoded data: `variable`.

5.8 table. Packet type field values

Value	Packet Type
0	Data packet requiring acknowledgment
1	Data packet NOT requiring acknowledgment
2	Acknowledgment packet

Acknowledgment packet should have the same *packet id* as acknowledged data packet and empty data payload. Acknowledgement should be sent in binary format (5.9 table).

5.9 table. Acknowledgment message

Constant Field		
Data Length Field	**Packet ID**	**Packet Type**
2 Bytes	*2 Bytes*	*1 Byte*

- *Data Length Field*: `0x0003`;
- *Packet ID* – same as in data packet;
- *Packet Type*: `0x02`.

9.3.2   Sending AVL data using UDP channel

AVL data are sent encapsulated in UDP channel packets (5.10 table).

5.10 table. UDP channel packet structure

AVL data encapsulated in UDP channel packet		
AVL packet ID	**Module IMEI**	**AVL data array**
1 Byte	*16 Bytes*	*...*

- *AVL packet ID* – id identifying this AVL packet;
- *Module IMEI* – IMEI of a sending module encoded the same as with TCP;
- *AVL data array* – array of encoded AVL data.

5.11 table. Server response message structure

Server response to AVL data packet	
AVL packet ID	**Number of accepted AVL elements**
1 Byte	*1 Byte*

- *AVL packet ID* – id of received AVL data packet;
- *Number of accepted AVL data elements* – number of AVL data array entries from the beginning of array, which were accepted by the server.

9.3.3   Communication with server

Module sends UDP channel packet with encapsulated AVL data packet (*Packet* type=1 or 0). If packet type is 0, server should respond with valid UDP channel acknowledgment packet. Since server should respond to the AVL data packet, UDP channel acknowledgment is not necessary in this scenario, so *Packet type=1* is recommended.

Server sends UDP channel packet with encapsulated response (*Packet type=1* – this packet should not require acknowledgment)

Module validates *AVL packet id* and *Number of accepted AVL elements.* If server response with valid *AVL packet id* is not received within configured timeout, module can retry sending.

Example:
1. Module sends data packet:
   FM → 00FDCAFE01DD000F31333435363738393031323334350802…(data elements)…02
   - 00FD – data length converted to decimal: 253;
   - CAFE – packet ID;
   - 01 – packet type (without acknowledgment);
   - DD – AVL packet ID;
   - 000F31333435363738393031323334350 – IMEI;
   - 08 – codec ID;
   - 02 – number of data (encoded using continuous bit stream);
   - …(data elements)… - AVL data array;
   - 02 – number of data.

2. Server acknowledges data reception:
   0005ABCD01DD02 ← Server
   - 0005 – packet length;
   - ABCD – packet ID;
   - 01 – packet type;
   - DD – AVL packet ID;
   - 02 – number of accepted data.

10 DATA SENDING – SMS

AVL data or events can be sent encapsulated in binary SMS. TP-DCS field of these SMS should indicate that message contains 8-bit data (for example: TP-DCS can be 0x04).

6.1 table. SMS data

SMS data (TP-UD)	
AVL Data Array	**IMEI**
…	*8 Bytes*

- *AVL Data Array* – array of encoded AVL data;
- *IMEI* – IMEI of sending module encoded as a big endian 8-byte long number.

10.1 24 position SMS data protocol

24-hour SMS is usually sent once every day and contains GPS data of last 24 hours. TP-DCS field of this SMS should indicate that message contains 8-bit data (i.e. TP-DCS can be 0x04).

Note, that 24 position data protocol is used only with subscribed SMS. Event SMS use standard AVL data protocol.

10.1.1   Encoding

To be able to compress 24 GPS data entries into one SMS (140 octets), the data is encoded extensively using bit fields. Data packet can be interpreted as a bit stream, where all bits are numbered as follows:

6.2 table. 24 GPS data entries structure

Byte 1	Byte 2	Byte 3	Bytes 4-…
Bits 0-7	Bits 8-15	Bits 16-24	Bits 25-…

Bits in a byte are numbered starting from least significant bit. A field of 25 bits would consist of bits 0 to 24 where 0 is the least significant bit and bit 24 – most significant bit.

10.1.2   Structure

6.3 table. SMS data structure

SMS Data Structure					
Codec ID	Timestamp	Element Count	GPS Data	Byte – align padding	IMEI
8 bits	*35 bits*	*5 bits*	*Element Count*		*64 bits*

- *Codec ID* – packet ID: 4;
- *Timestamp* – Time corresponding to the first (oldest) GPS data element, represented in seconds elapsed from 2000.01.01 00:00 EET;
- *Element Count* – Number of GPS data elements;
- *GPS Data* – GPS data elements;
- *Byte* – align padding – Padding bits to align to 8-bits boundary;

- *IMEI* – IMEI of sending device as 8-byte long integer.

The time of only the first GPS data element is specified in *Timestamp* field. Time corresponding to each further element can be computed as e*lementTime = Timestamp* + (1 hour * elementNumber).

6.4 table. GPS data

GPS Data						
Valid Element	**Differential Cords**	**Longitude Diff**	**Latitude Diff**	**Longitude**	**Latitude**	**Speed**
		Differential Cords = 1		**Differential Cords = 0**		
1 bit	*1 bit*	*14 bits*	*14 bits*	*21 bits*	*20 bits*	*8 bits*

- *Valid Element* – Valid Element=1, there is a valid GPS Data following, Valid Element=0, no element at this position;
- *Differential Cords* - format of following data;
- *Longitude Diff* – Difference from previous element's longitude. Longitude Diff = prevLongitude – Longitude + 2^{13} – 1;
- *Latitude Diff* – Difference from previous element's latitude Latitude Diff = prevLatitude, Latitude + 2^{13} – 1;
- *Longitude* – longitude={(LongDegMult + 18 * 10^8) * (2^{21} – 1)} over {36*10^8};
- *Latitude* – latitude=(LatDegMult + 9*10^8) * (2^{20} – 1) over {18*10^8};
- *Speed* – Speed in km/h.

- *Longitude* – longitude field value of GPS Data;
- *Latitude* – latitude field value of GPS Data;
- *LongDegMult* – longitude in degrees multiplied by 10^7 (integer part) ;
- *LatDegMult* – latitude in degrees multiplied by 10^7 (integer part);
- *prevLongitude* – longitude field value of previous GPS Data;
- *prevLatitude* – latitude field value of previous GPS Data.

10.1.3 Decoding GPS position

When decoding GPS data with Differential Cords=1, *Latitude* and *Longitude* values can be computed as follows: *Longitude=prevLongitude – LongitudeDiff +* 2^{13} – 1, Latitude=*prevLatitude – LatitudeDiff +* 2^{13} – 1.

If there were no previous non-differential positions, differential coordinates should be computed assuming prevLongitude=prevLatitude=0.

When *Longitude* and *Latitude* values are known, longitude and latitude representation in degrees can be computed as follows (6.1 and 6.2):

$$Longitude = \frac{Long*36}{2^{21}-1}$$ (6.1)

$$\frac{Lon18}{Lat\frac{365}{24}}$$ (6.2)

11 DEEP SLEEP MODE

While in deep sleep mode, FM5300 sets GPS receiver to sleep mode and turns off GSM/GPRS module (it is not possible to wake up device via SMS), therefore records with last good coordinates are being saved and send to AVL server if configured (GSM/GPRS module is turned on to send data and after turned off). Depending on two configurable parameters, send period and min period, in Deep Sleep mode power usage can be decreased to save vehicle's battery.

FM5300 can enter deep sleep mode (standby mode) if **ALL** of these conditions are met:
- FM1100 has to be configured to work in Deep Sleep mode;
- Startup timeout has elapsed (5 minutes after every restart of the device);
- No movement by accelerometer is detected;
- Ignition (DIN1) is off (driven logic low);
- Send period in stop mode is more than 60 seconds (Data Acquisition Mode settings);
- USB cable is not connected.

FM5300 exits deep sleep mode when if **ONE** of following conditions are true:
- Movement by accelerometer is detected (depends on accelerometer start settings);
- Ignition (DIN1) is turned on (driven logic high);
- USB cable is connected;
- HIGH or PANIC priority eventual record is detected;

While being in deep sleep mode FM5300:
- can save periodical or eventual records;
- send data to server;

Note: If there is no need to save or send periodical data FM53 have to be configured to switch to another profile on Deep Sleep Event where Min Period and Send Period parameters are 0 or big enough.

Note: In order to save GPRS traffic records saved in deep sleep mode contains below listed I/O elements information:
Digital Inputs (1-4), Analog Inputs (1-4), Battery Voltage, Battery Current, Digital Outputs (1-4), External Voltage, Movement Sensor, Deep Sleep.
Also, Deep Sleep I/O is always LOW PRIORITY!

12 FEATURES AND SCENARIOS.

12.1 Eco Driving Scenario

Four scenarios are available on FM11 device.
Digital Output No.1 is used by scenarios - Eco Driving **or** Over Speeding;
Digital Output No.2 is used by scenarios - Authorized Driving **or** Immobilizer.

Eco Driving Scenario. Helps to prevent and inspect driver about harsh driving. Scenario continuously monitors: accelerating, braking and cornering forces. Inspects driver if needed. Monitoring sensitivity is configurable.

DOUT1 is controlled by scenario for user needs, buzzer or LED for example. Output activation time after harsh event is also configurable.

Because functionality generally is dependent on accelerometer it is important to calibrate it on time. User can choose from two different calibration methods or use them both.

To save GPRS traffic Green Driving event will be **generated (included into send records) only** when FM1100 measured values are higher than those set in configuration, without additional I/O settings.

To prevent generating false events, **Eco Driving** only functioning when special conditions are fulfilled – mentioned below.

12.1.1   Mounting Requirements

PLEASE PAY ATTENTION, that ECO driving functionality will operate correctly only if device is mounted into the vehicle in proper position.

Eco Driving functionality operation is based on accelerometer. It is important to mount FM5300 device correctly to avoid functionality malfunctions (first condition). In the picture below (Figure 45) mounting recommendations are displayed. Please **note** that beside those recommendations

1. You can choose how FM5300 is deployed. It means that that there is no effect to measurements if FM5300 top/bottom side pointing up or down.
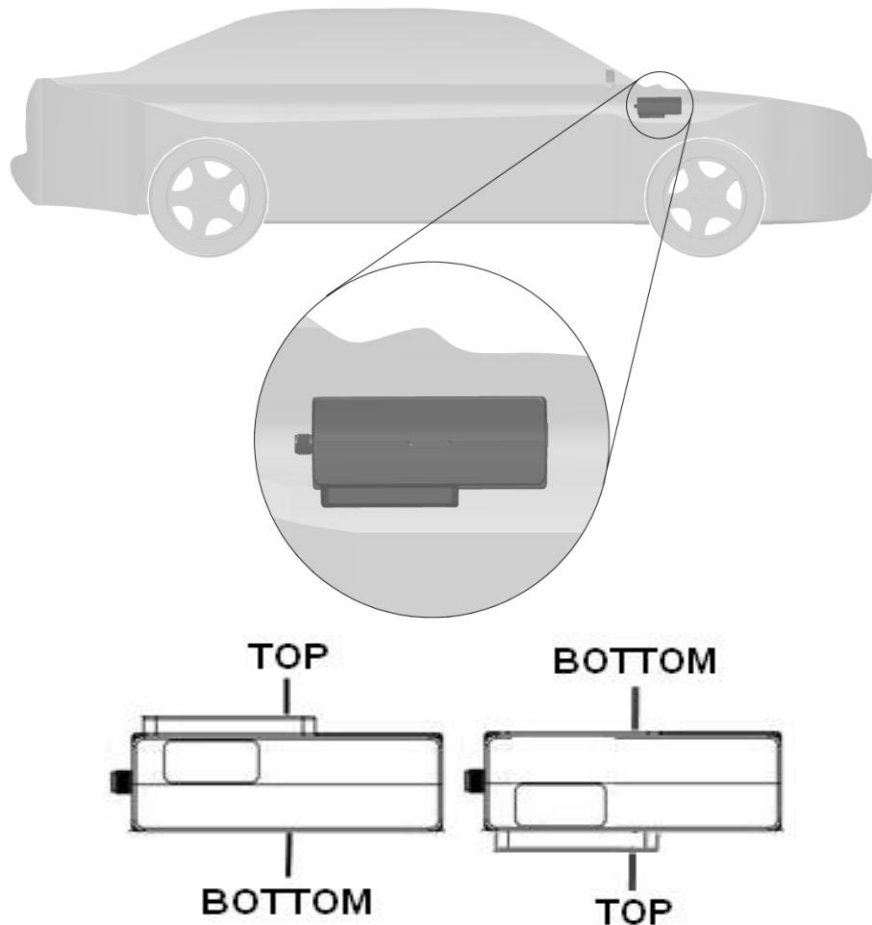2. Device can be deployed at any place in the car.

Figure 45 Correct mounting position of the FM5300 in the vehicle

To Eco Driving work properly device connection pins socket must be pointing towards vehicle front side. Deviation of +/- 2° are allowed. But it should be as straight as possible. Deviation of max. +/- 15° is allowed (Figure 46).
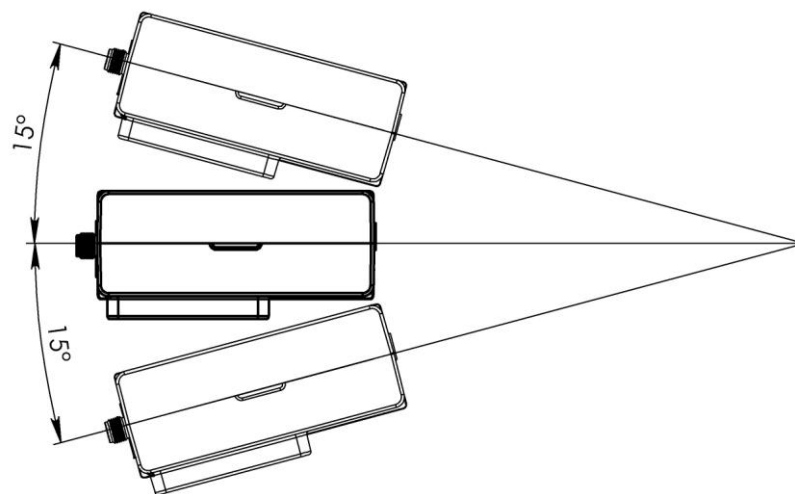

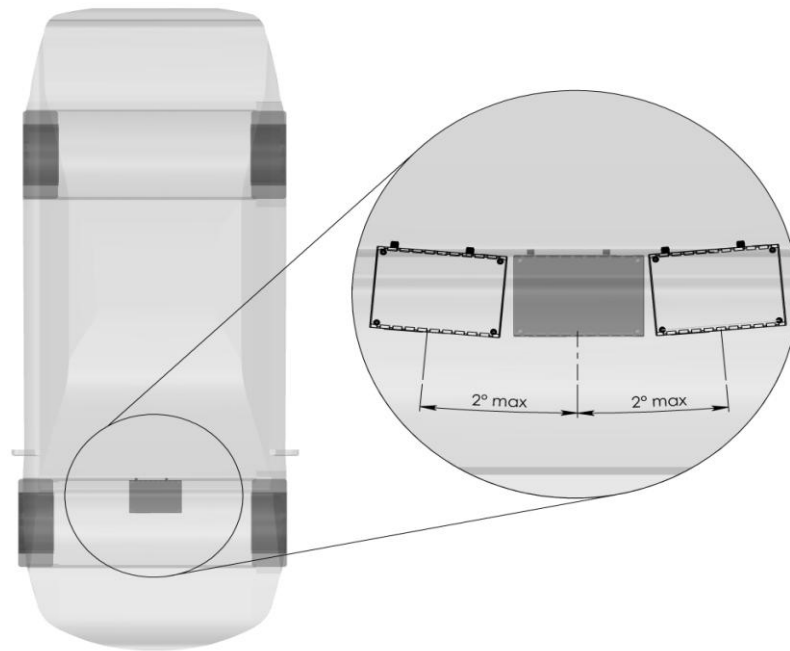**Figure 46 MAX deviation from horizon plane of FM5300 mounting**

Figure 47 Horizontal position MAX deviation of FM5300 mounting

Horizontal position must be as flat as possible – parallel with vehicle plain.

12.1.2   Configuration

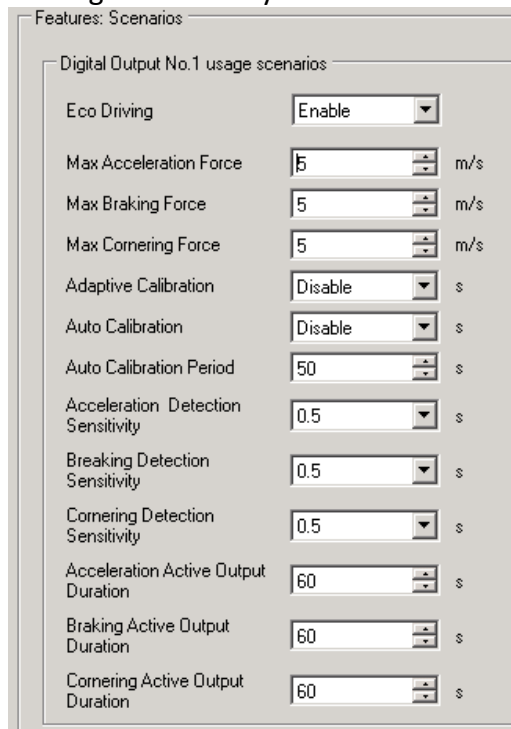Parameters used with Eco driving functionality.

Figure 48

Table 18 ECO Driving parameters description

ECO driving configuration parameter name	Description
Eco Driving	Enable/Disable Eco Driving functionality
Max Acceleration Force	Value which can be reached while accelerating without triggering harsh acceleration event.
Max Braking Force	Value which can be reached while braking without triggering harsh braking event.
Max Cornering Force	Value which can be reached while cornering without triggering harsh cornering event.
Adaptive Calibration	Enable/Disable Adaptive Calibration. This method of calibration monitors vehicle horizontal plain position. Usually vehicle position changes while driving uphill or downhill. If required level of horizontal plain position change is detected, FM5300 device automatically adapts to new position.
Auto Calibration	Enable/Disable Automatic Calibration. FM53 device calibrates itself periodically. Independent from vehicle position.
Auto Calibration Period	Set how often calibration is carried out.
Acceleration Detection Sensitivity	Lower the value to increase sensitivity. Increasing sensitivity means that more acceleration can/will be detected on the same period of time. Response time decreases.
Braking Detection Sensitivity	Lower the value to increase sensitivity. Increasing sensitivity means that more braking can/will be detected on the same period of time. Response time decreases.
Cornering Detection Sensitivity	Lower the value to increase sensitivity. Increasing sensitivity means that more cornering can/will be detected on the same period of time. Response time decreases.
Acceleration Active Output Duration	Set active ouput duration after harsh acceleration event detected
Braking Active Output Duration	Set active ouput duration after harsh braking event detected
Cornering Active Output Duration	Set active ouput duration after harsh cornering event detected

Example: Set Acceleration Detection Sensitivity to "0.5". In this case driver can accelerate not longer than 0.5 second so Eco Driving functionality can detect acceleration. If acceleration lasts 1.2 seconds two harsh acceleration events will be detected/generated.
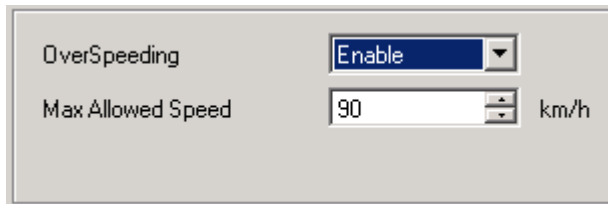
12.2 Overspeeding Scenario

Overspeeding. Helps to prevent from exceeding fixed speed and inspects driver if needed. DOUT1 is controlled by scenario for user needs, to manage buzzer, LED etc.

12.2.1 Mounting Requirements and Working Conditions

1. Only one scenario on corresponding Digital Output can be enabled at once .
2. Scenarios on Digital Output No.1 and Digital Output No.2 can be used simultaneously.
3. Device module mounting position doesnt have any influence for correct scenarios activity

12.2.2 Configuration.

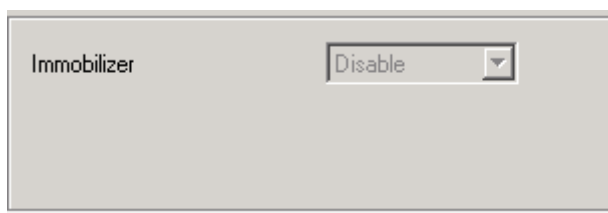**Figure 49 Overspeeding configuration parameters**

Overspeeding. Enable/Disable Overspeeding.
Max Allowed Speed. Set speed limit to reach without triggering Overspeeding event.

12.3 Immobilizer Scenario

Immobilizer. Vehicle can be used only if iButton is connected. In this scenario iButton list is not used; connect any iButton to pass Immobilizer security. DOUT2 is controlled by scenario for user needs.

12.3.1 Configuration.

Figure 50 Immobilizer configuration parameters

Immobilizer. Enable/Disable Immobilizer Scenario.

12.4 Authorized Driving Scenario

Authorized Driving. Gives ability to use vehicle only for 50 specific iButton owners (specified in iButton list). DOUT2 is controlled by scenario for user needs, to manage buzzer, LED etc.
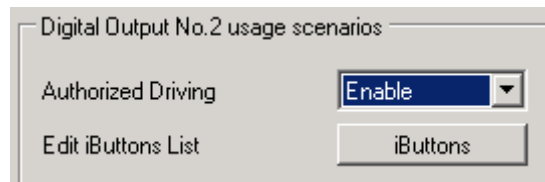
12.4.1 Configuration.

Figure 51Authorized driving configuration parameters

Authorized Driving. Enable Disable Authrized Driving.
Edit iButtons List. Enter authorized iButtons

13 CHANGE LOG

Nr.	Date	Version	Comments
1	2011-11-16	0.0	Preliminary draft release.
2	2011-11-27	0.1	Added 5-12 chapters, minor changes in 1-4 chapters