MECHATRONICS

Eurosens Degree BT tilt angle sensor

Operation manual

1. General information

The Eurosens Degree Bt wireless tilt angle sensor is designed to measure the angular position of parts and mechanisms relative to the gravity vector and transmit this data over a 2.4 GHz radio channel Bluetooth Low Energy (BLE). The sensor is self-powered from a built-in battery. Android Application for smartphone is used for the sensor configuration.

Fig. 1. Tilt angle sensor

Sensor modifications:

Eurosens Degree Bt – wireless tilt angle sensor
Eurosens Degree Bt T – wireless tilt angle and temperature sensor
Eurosens Degree Bt M – wireless tilt angle sensor and event logger
Eurosens Degree Bt MT – wireless tilt angle and temperature sensor and event logger

Sensor consists from casing and electronic module with ER14505 battery (AA size).

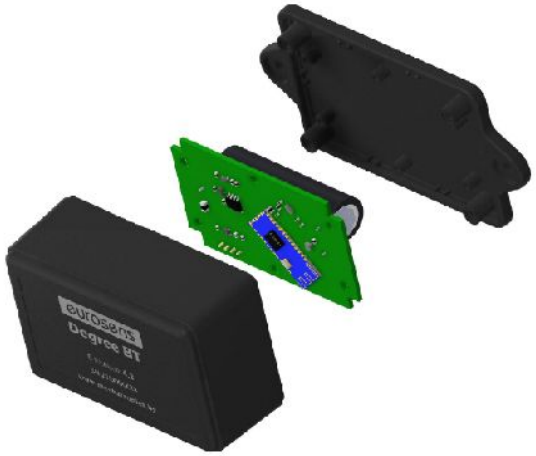


Fig. 2. Tilt angle sensor

Table 1. Sensor datasheet.

Name of parameter	**Value**
Radio frequency	2,4 GHz
Battery voltage	3 ... 3,7V
Time of operation from battery	3 years
Data interface	Bluetooth Low Energy (BLE)
Sensitivity of receiver /power of transmitter	-96 dBm / +4 dBm
Data protocol	Advertising-packet (see Appendix 1)
Connection range (in direct visibility)	10 meters
Tilt angle measurement error	±1°
Temperature measurement error	±1°C
Number of records of events (for devices with datalogger function)	900
Operation temperature range	- 40 ... + 85 ^{0}C
IP protection class	IP67
Dimensions	100x100x50
Weight, kg	0,3

2. Sensor operation

2.1 Tilt angle monitoring mode with events detection

The sensor measures 3 tilt angles of the coordinate axes relative to the gravity vector.
Pay attention to the possibility of measuring various deviations of the object - measurement is possible only if the position of the sensor changes relative to the gravity vector (see Fig. 3-4).

Fig. 3. This measurement is possible

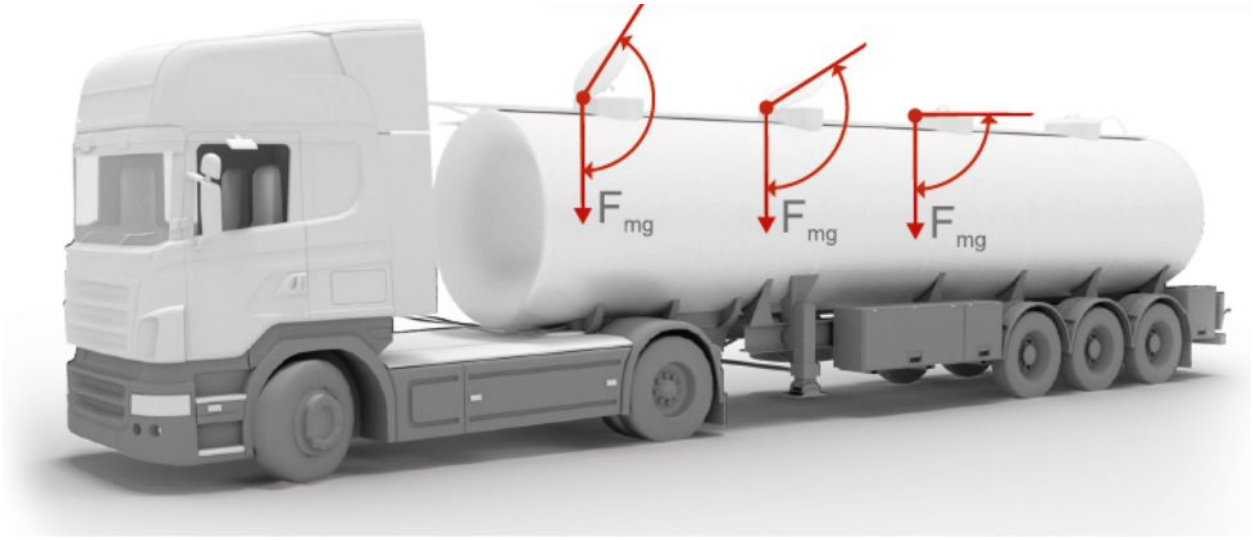


Fig. 4. Monitoring of the tank locks - possible

Fig. 5. Door monitoring – not possible

The sensor transmits the measured values of 3 angles relative to the gravity vector using the BLE protocol and is compatible with such GPS tracking devices terminals as Teltonika, SMART (Navteletom), Neomatica, Fort-Monitor and others. Check compatibility with our technical support. The description of the data package is given in Appendix 1.

In addition to measuring the tilt angles, the sensor independently determines Events and Chains of events.
An event is detected when angle have gone beyond the specified boundaries. One event can be configured for each of the axes (X, Y, Z). When an event occurs, the event counter is incremented by one.

A chain of events is the fulfillment of the conditions of a sequence of events separated by time intervals. For each of the events, an axis of angle measurement, an angle value and a

comparison type (<,>) are specified. The maximum waiting time for the next condition is also set.

Fig.6. First event of the chain : angle <100

Expecting next event during 5 seconds

Fig.7. Second event of the chain : angle >100

Expecting next event during 3 seconds

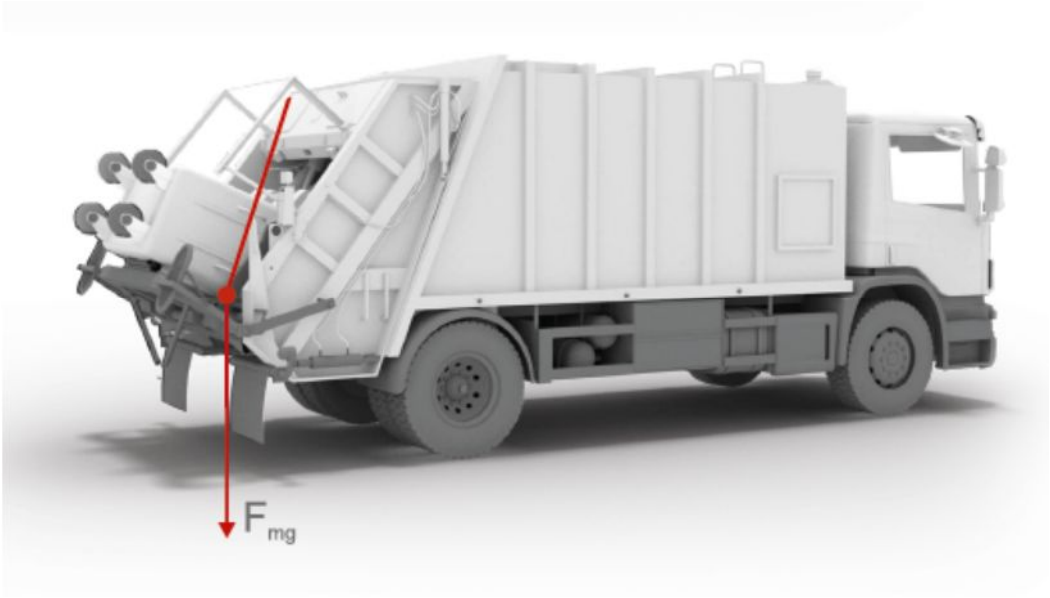


Fig.8. Third event of the chain : angle >150

When a chain of events is executed, the chain counter is incremented by one.

The numbers of events and event chains are transmitted over the BLE protocol. So you don't need to process X,Y,Z angle values in your tracking software to detect an event. Moreover frequent data transmission could drain the battery.

We recommed to setup the internal event/chain of events detection engine to avoid missing the important events.

2.2 Drum rotation mode

In this mode the sensor expects to be installed on the external surface of a rotating drum. This mode is used for concrete mixer monitoring. Sensor measures the rotation speed of the drum (signed value, negative or positive stands for the direction of rotation) and calculates total time of rotation and number of drum starts.

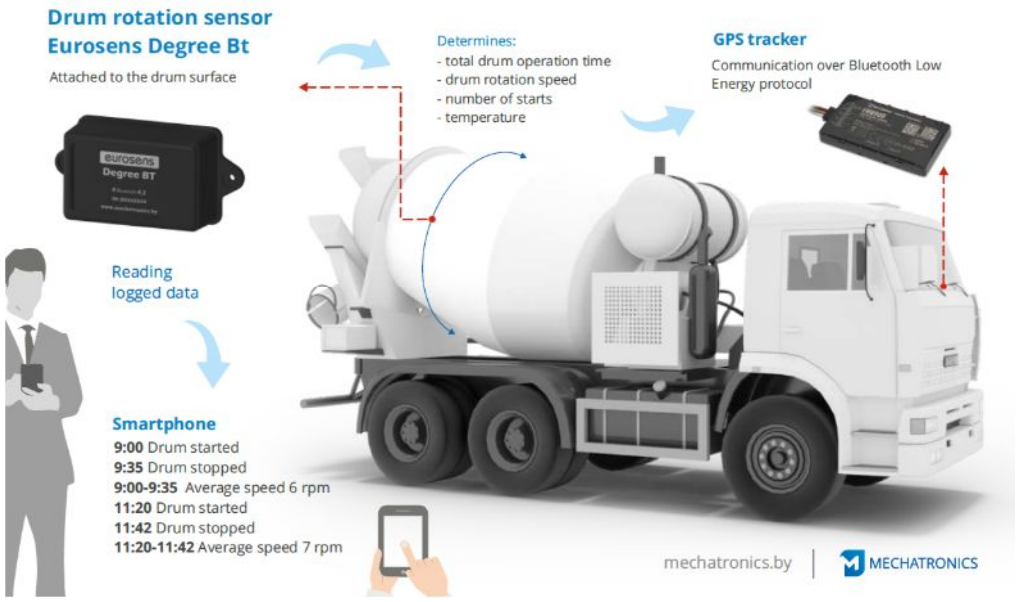


Fig. 9. Eurosens Degree BT in the drum rotation mode.

2.3 Boom control mode

In this mode, the sensor controls the boom movement. The measurement of the angles in this case is not as important as the total operation time (Fig. 10). At the same time, during the work process, it is impossible to constantly move, therefore, the permissible pauses between the stops of the working body are set in the sensor settings. If the duration of pause is less than limit, then the stop time is considered to be operation.

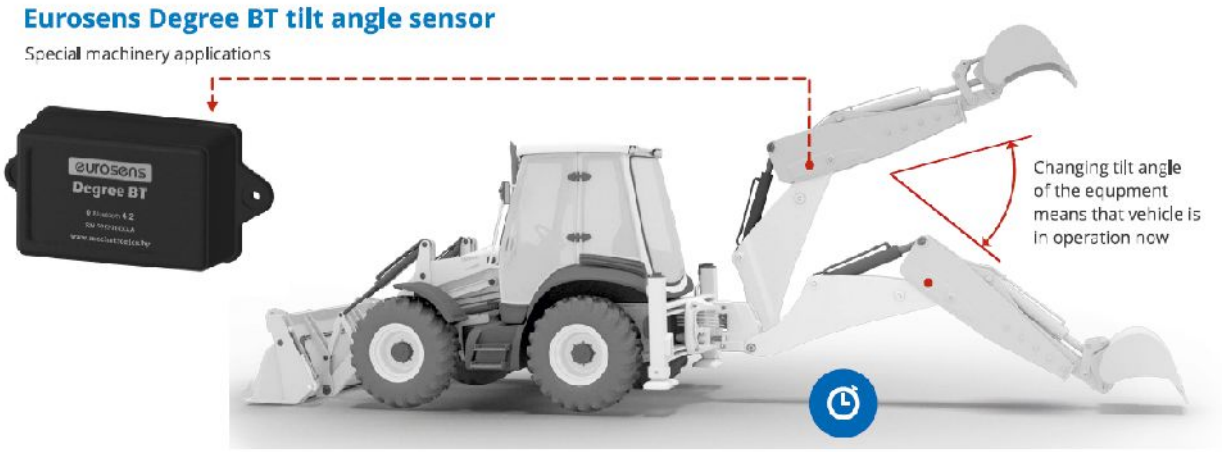


Fig. 10. Eurosens Degree BT sensor in a Boom control mode

3. Sensor setup

Download the Eurosens Degree Bt configuration software. Switch ON Bluetooth module and start the software.

Bluetooth Low Energy search will start. (fig. 11)

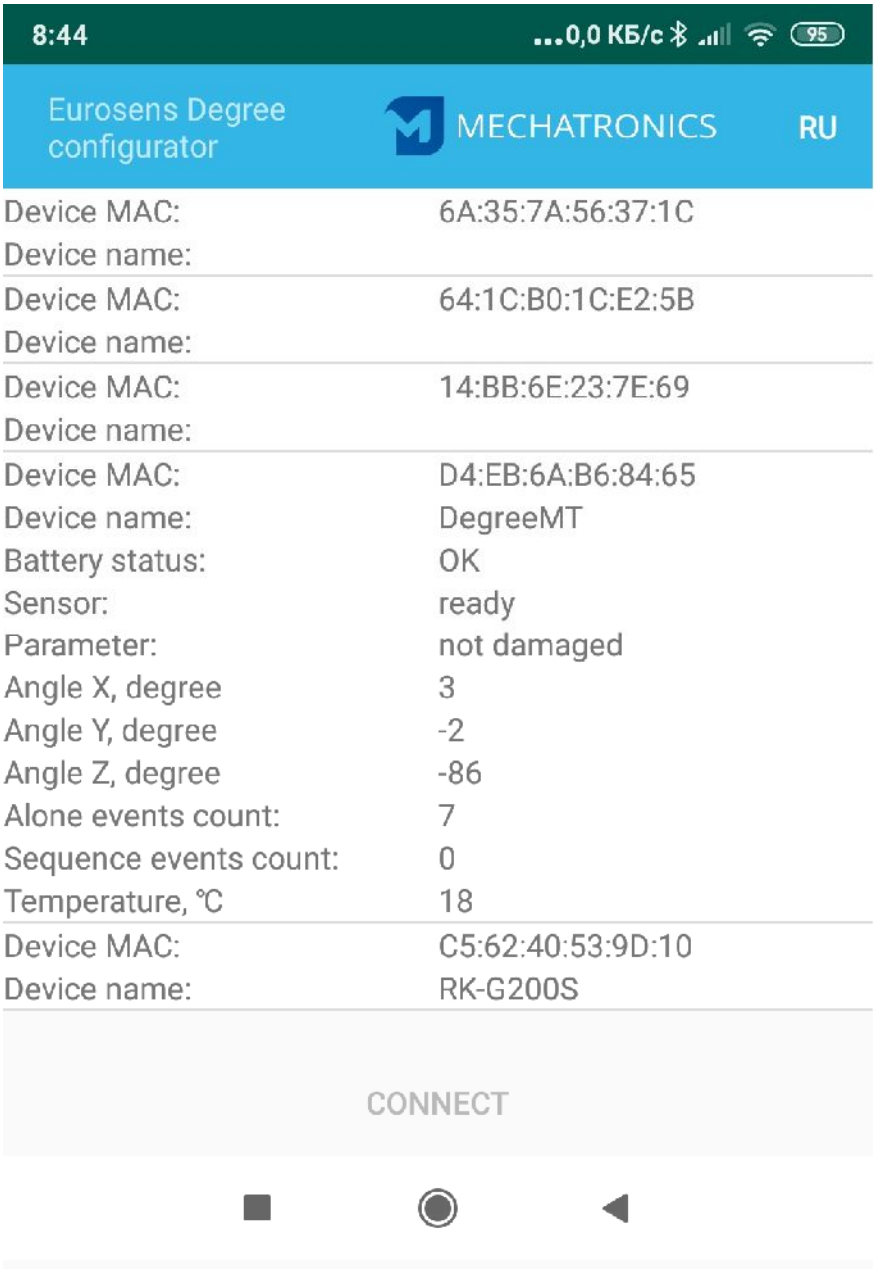


Fig. 11. Bluetooth device search

Select the Eurosens Degree device and click **Connect**

Settings page contains information about sensor and its settings (fig. 12)**.**

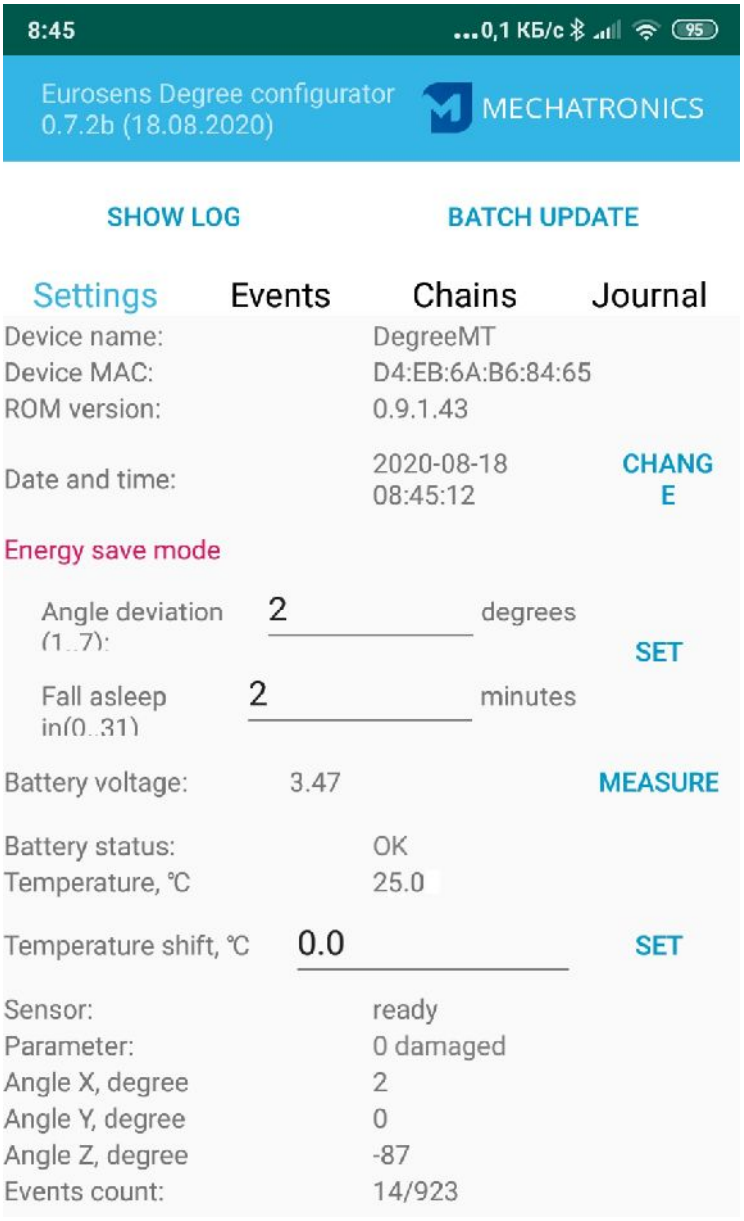


Fig. 12 – Device settings

Device MAC: contains the unique MAC-address of the sensor. It is used in connection to GPS trackers by BLE protocol.
ROM version : sensor firmware version
Date and time : sensor data and time

Angle deviation and Fall asleep in : time in minutes to send sensor in a sleep mode without movement. Angle deviation value defines angle movement detection. Value “2” means angle changes below 2 degrees are counted as no movement. Sleep mode is recommended for power economy.

Battery voltage : voltage of the internal battery in volts.
Temperature : temperature of the internal sensor
Temperature shift : correction of the temperature sensor.
Sensor status : ready/not ready

Parameter 0 damaged : diagnostic message to test memory. Shows the number of damaged parameter.

Angle X, Y, Z : measured angle in degrees relative to gravity vector.

Events count : 0/923. Number of detected events/maximum number of events could be stored in memory with details (ID of event, time). Number of detected events can be bigger than maximum number of stored events.

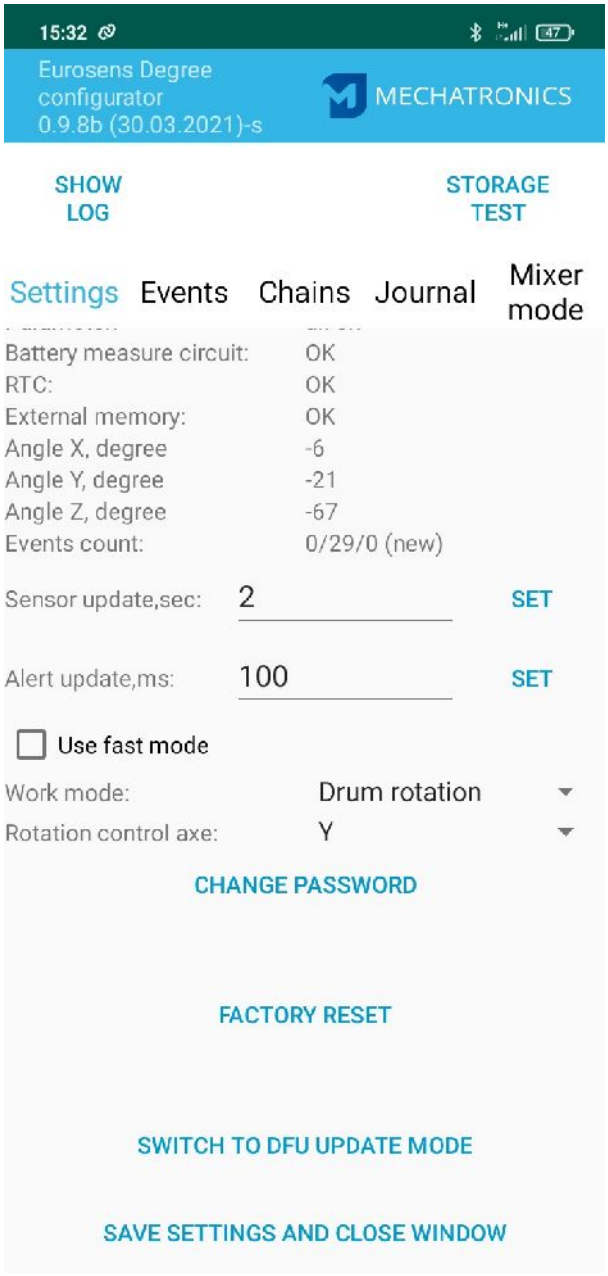


Fig. 13 - Device settings (end of screen)

Sensor update, s : time interval between sending advertising packets
Alert update,s : time delay to send a message after event was detected.
Fast mode : When ON internal accelerometer is updating with 12,5 Hz speed. When Off more power-saving mode of 1.6 Hz is used.

Work mode determines one of the sensor operation algorithms (see section 2). When choosing Concrete Mixer or Manipulator mode, you need to set the axis to control. Examples of choosing a control axis are shown in Fig. 14.

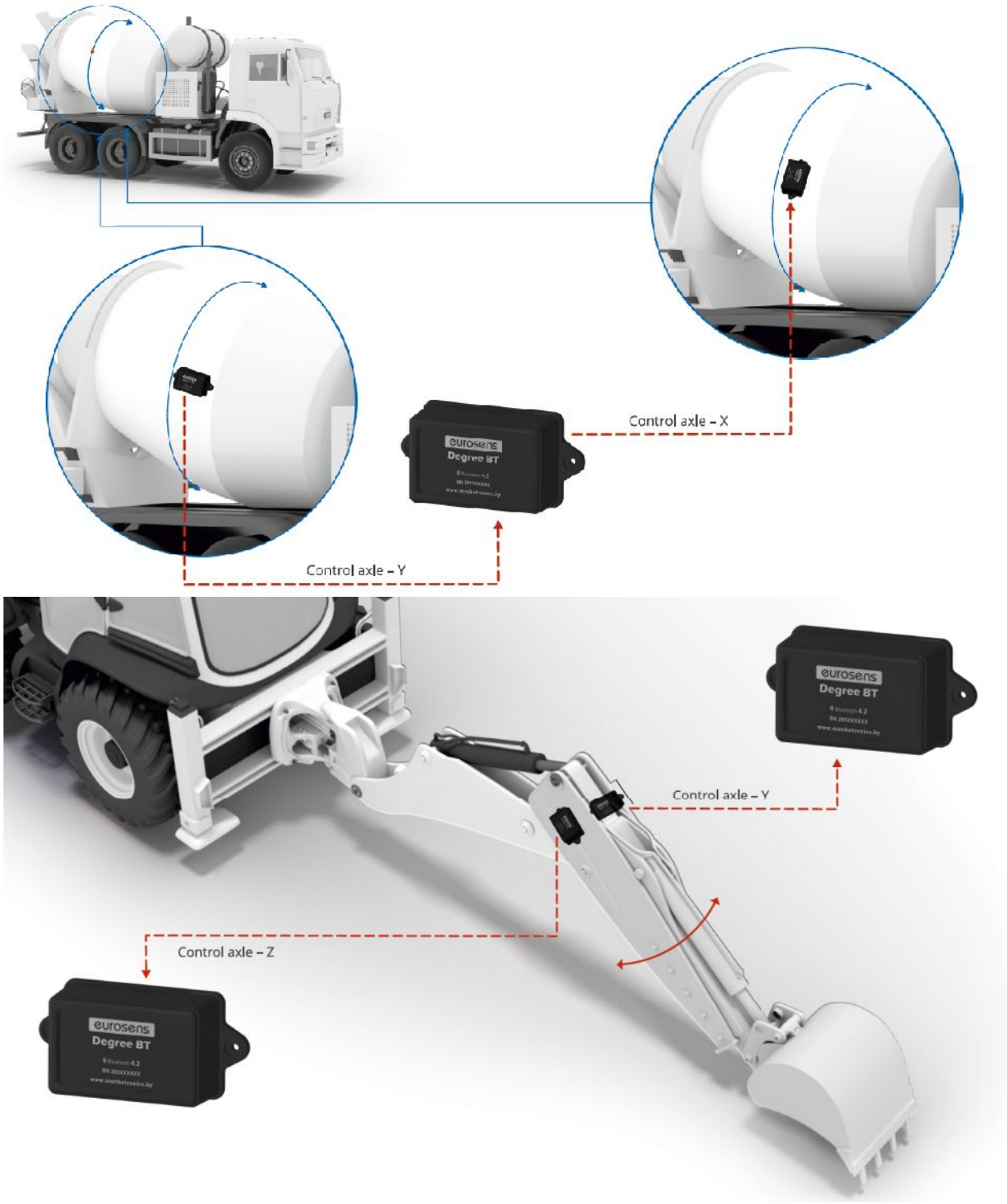


Fig.14 Choosing rotation control axe

Fastory reset will reset sensor to the factory default settings.
Switch to DFU update mode – see Updating sensor firmware.

Limit data tab (fig. 15)

Here you can set boundary angles for events detection.
You can assign 1 angle for each axis.

Enable control : means angle event detection is activated or not.
Smoothing : angle value averaging ON/OFF

Hysteresis : deviation from boundary value.
Example : Boundary value > 45 and hysteresis 2
Event is generated when angle >44 (45±1)

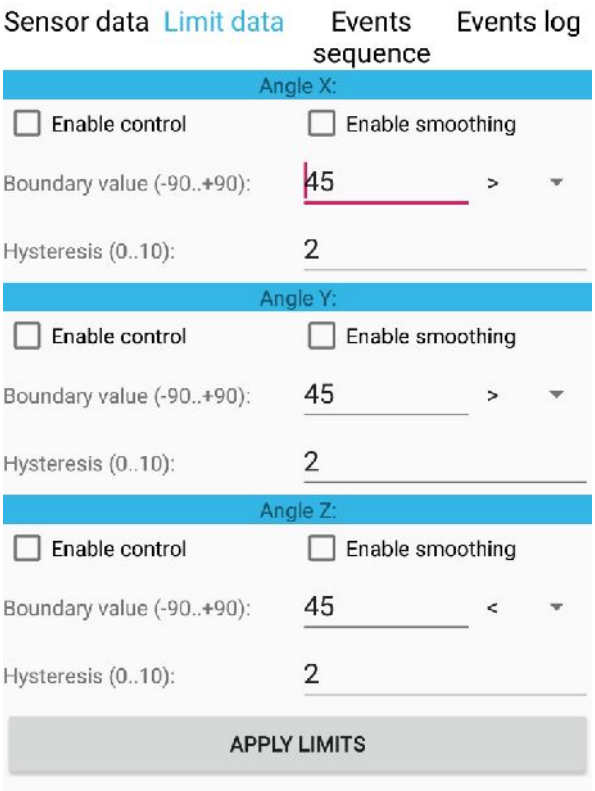


Fig. 15

Events sequence tab (Fig. 16).

You can create here one event sequence to be analyzed by sensor.
Add button allows to add new event to the sequence.
Maximum seconds – maximum time of event before transforming to the next step.

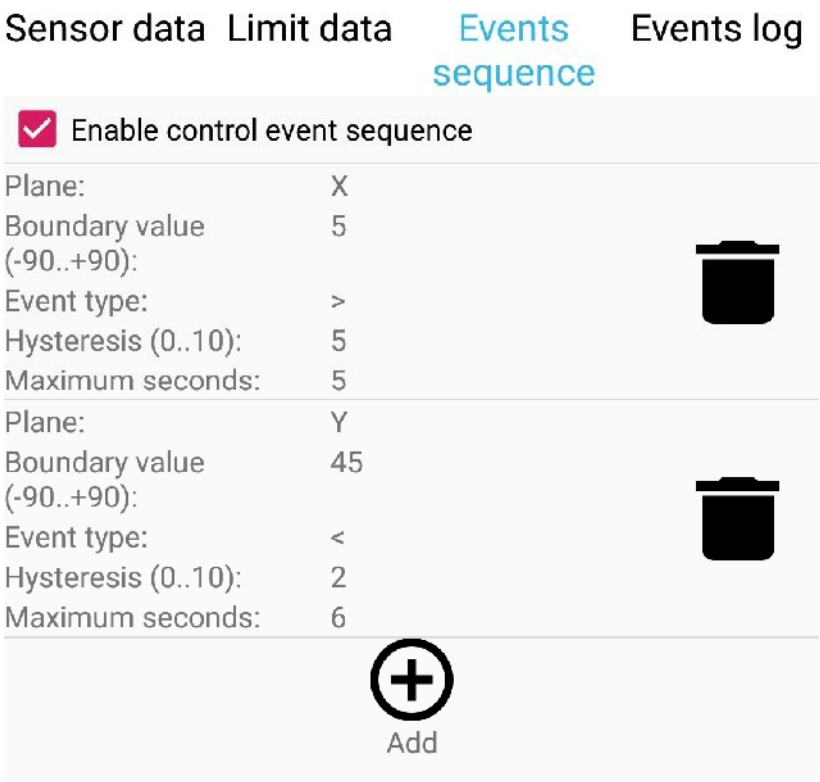


Fig.16

In example from fig.16 :
First event of the sequence will be detected then angle X becomes greater than 5 degrees. Immediately, sensor engine will wait 5 seconds for the next event. IF second event (Y<45 degrees) not happens in 5 seconds, event sequence won't be detected.

Events log tab (fig. 17)

Here you can see the journal of events. Available only for Degree M, Degree MT.
There are 4 possible events : X, Y, Z and Chain of events.

Type of event, its time cannot be translated by BLE protocol but you can review it by Eurosens Degree Bt configurator.

Maximum number of stored events is shown on Sensor data tab. After filling memory older records will be deleted.

Fig. 17

When sensor is in Drum operation mode you can see another tab containing the drum journal.

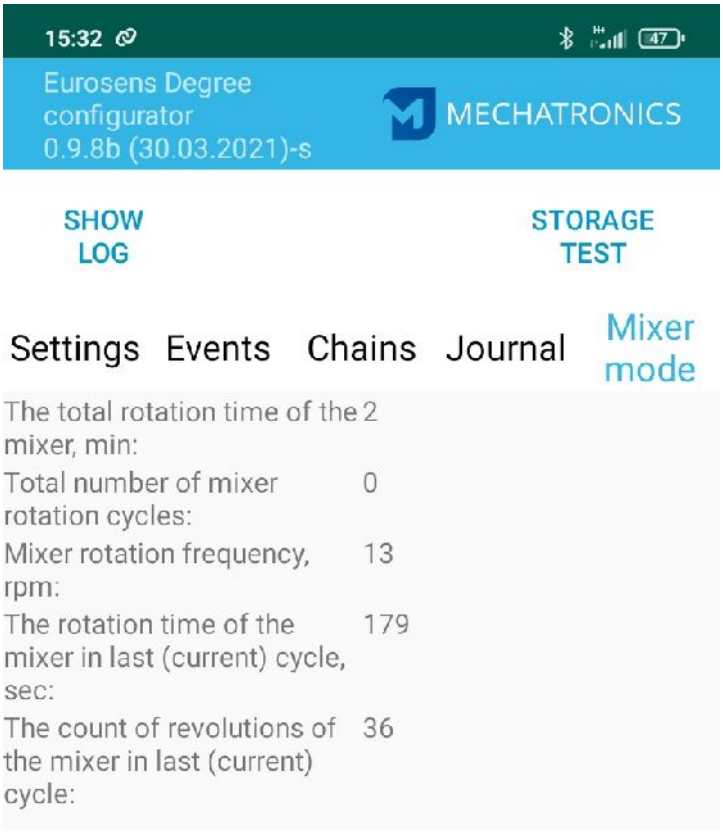


Fig. 18. Drum operation parameters

4. Updating Sensor firmware

Download and install nRFConnect application
https://play.google.com/store/apps/details?id=no.nordicsemi.android.mcp&hl=ru

Tap **Switch to DFU update mode** button in Sensor data tab.
Sensor will be disconnected from configurator.

Open nRFConnect and find DfuTarg device in the list. It is your sensor wanting for the new firmware upload. Choose “Connect” (Fig. 19).

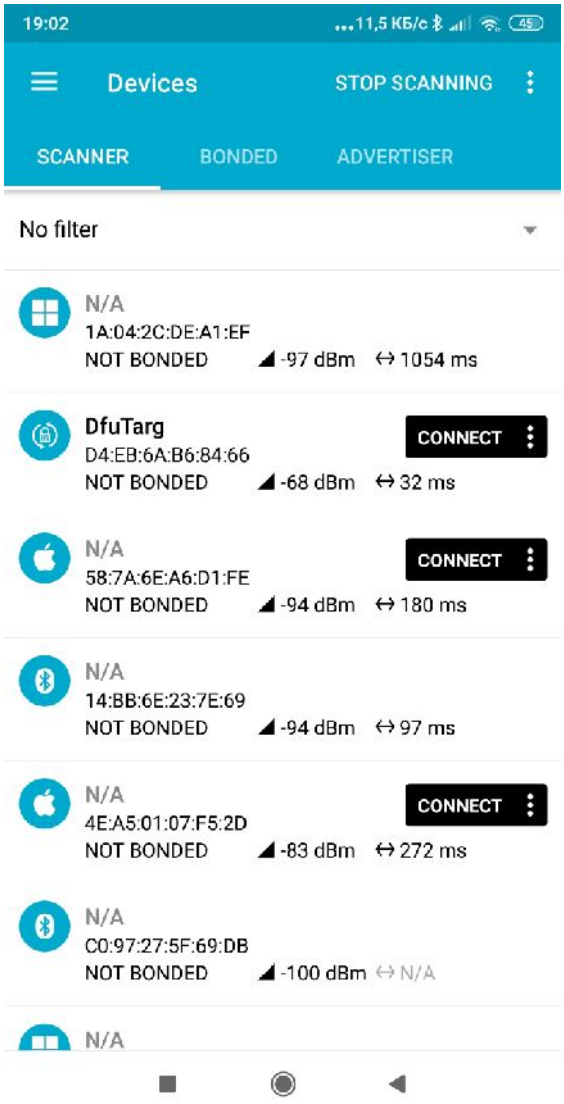


Fig. 19

Then tap on small DFU icon in the upper right corner (Fig. 20).

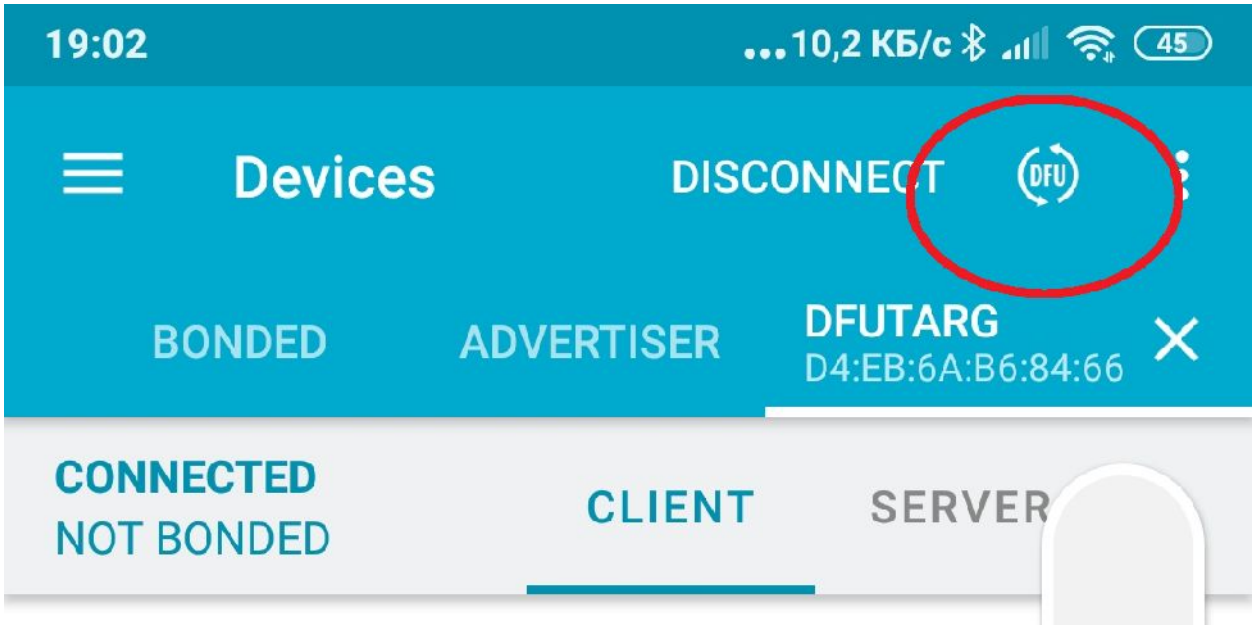


Fig. 20

Choose Distribution packet option and firmware file (fjg. 21).

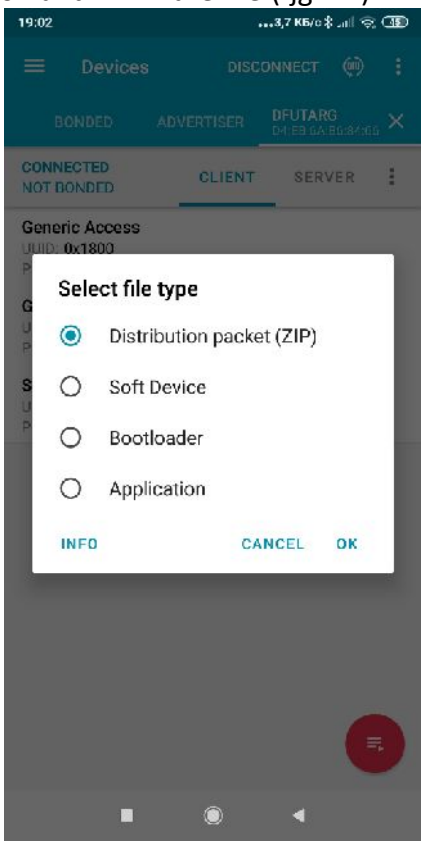


Fig.21

Upload will start shortly (fig. 22).

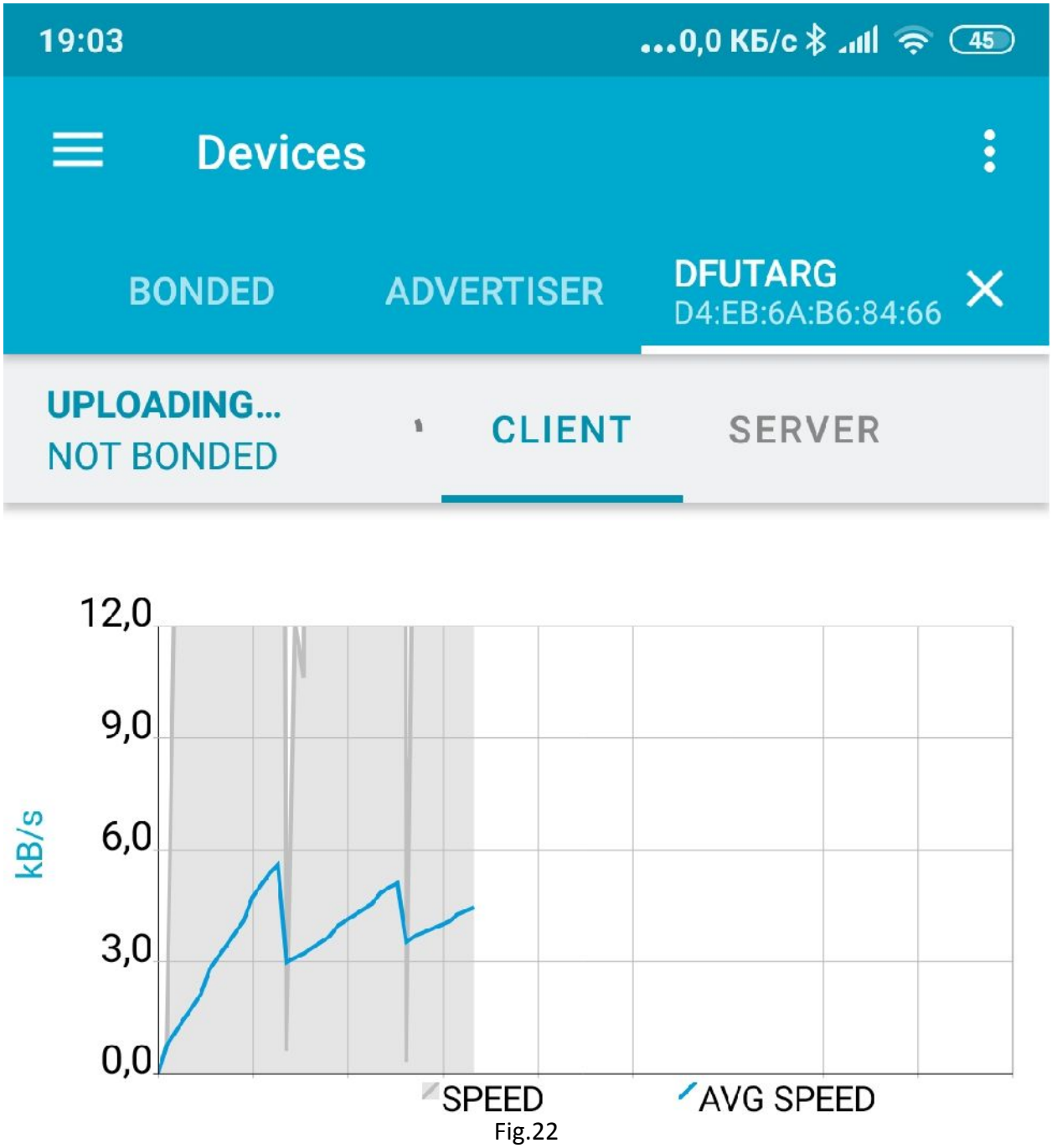


Fig.22

After firmware upload sensor will be disconnected from nRFConnect application.

Sensor is updated.

Appendix 1. Eurosens Degree Bt BLE protocol.

Eurosens Bt T, Euroens Bt MT

0x02010610FF59001700BE49000000001FFFFFFFFF0809446567726565541079ECADC240EE5A9E093F3A3B50100406E

Name of parameter	Comments	Example	Offset, bytes	Length, bytes
X-plane angle	-90°...+90°	0x17	7	1
Y-plane angle	-90°...+90°	0x00	8	1
Z – plane angle	-90°...+90°	0xBE	9	1
Byte of sensor status	Bit 1 – device is ready (1), not ready (0) Bit 2 – all settings are set (1), not set (0) Bit 3 – Low battery alarm Bit 4 - Password Bit 5-7 – battery level (0-7)	0x49	10	1
Number of events (singles)		0x0000	11	2
Number of complex events		0x0000	13	2
Temperature		0x1F	15	1
Serial number of the sensor		FFFFFFFF	16	4
Name of sensor	DegreeT DegreeMT	0x44656772656554 0x4465677265654D54	22 22	7 8

Appendix 2. Eurosens Degree Bt BLE protocol. Drum rotation measurement mode

Example of the RAW data of advertising packet
0x02010610FF590000FD56590006000214205000010909446567726565 4D4911079ECADC24 0EE5A9E093F3A3B50100406E

Name of parameter	Comments	Example	Offset, bytes	Length, bytes
Drum rotation speed, rpm	0…255	0x00	7	1
Y-plane angle	-90°...+90°	0xFD	8	1
Z – plane angle	-90°...+90°	0x56	9	1
Byte of sensor status	Bit 1 – device is ready (1), not ready (0) Bit 2 – all settings are set (1), not set (0) Bit 3 – Low battery alarm Bit 4 - Password Bit 5-7 – battery level (0-7)	0x59	10	1
Total time of drum rotation, minites		0x0006	11	2
Number of drum starts		0x0002	13	2
Temperature	Celsius	0x14	15	1
Serial number of the sensor		20500001	16	4
Name of sensor	DegreeMI	4465677265654D49	22	8

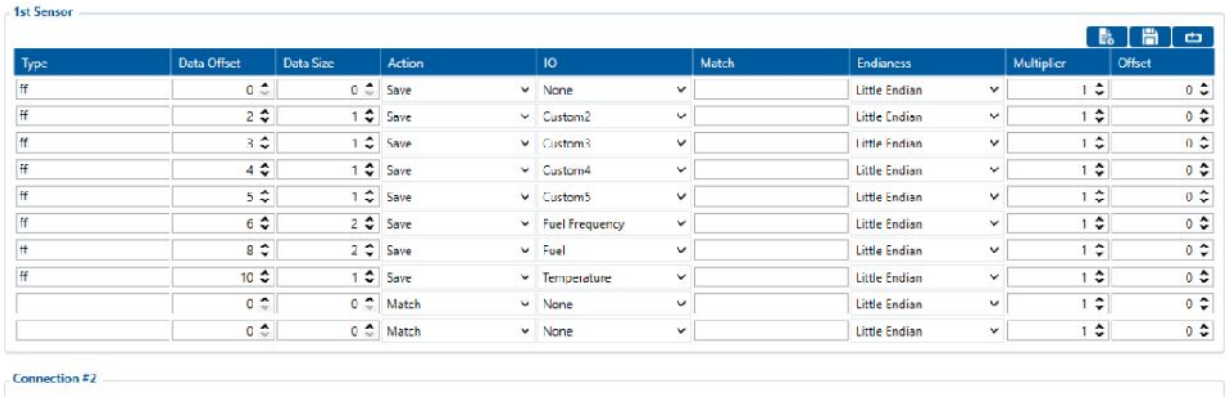
Appendix 3. Eurosens Degree Bt BLE protocol. Excavator mode.

Example of the RAW data of advertising packet
0x02010610FF590004FEAC590001DF381FFFFFFFFF0909446567726565455811079ECADC240EE5A9E093F3A3B50100406E

Name of parameter	Comments	Example	Offset, bytes	Length, bytes
X-plane angle	-90°...+90°	0x04	7	1
Y-plane angle	-90°...+90°	0xFE	8	1
Z – plane angle	-90°...+90°	0xAC	9	1
Byte of sensor status	Bit 1 – device is ready (1), not ready (0) Bit 2 – all settings are set (1), not set (0) Bit 3 – Low battery alarm Bit 4 - Password Bit 5-7 – battery level (0-7)	0x59	10	1
Status of operation	0 – not working 1 - working	0x0001	11	2
Total time of operation		0xDF38	13	2
Temperature	Celsius	0x1F	15	1
Serial number of the sensor		FFFFFFFF	16	4
Name of sensor	DegreeMI	4465677265654558	22	8

Appendix 4. Example of Teltonika FMBXXX setup with Eurosens Degree BT.

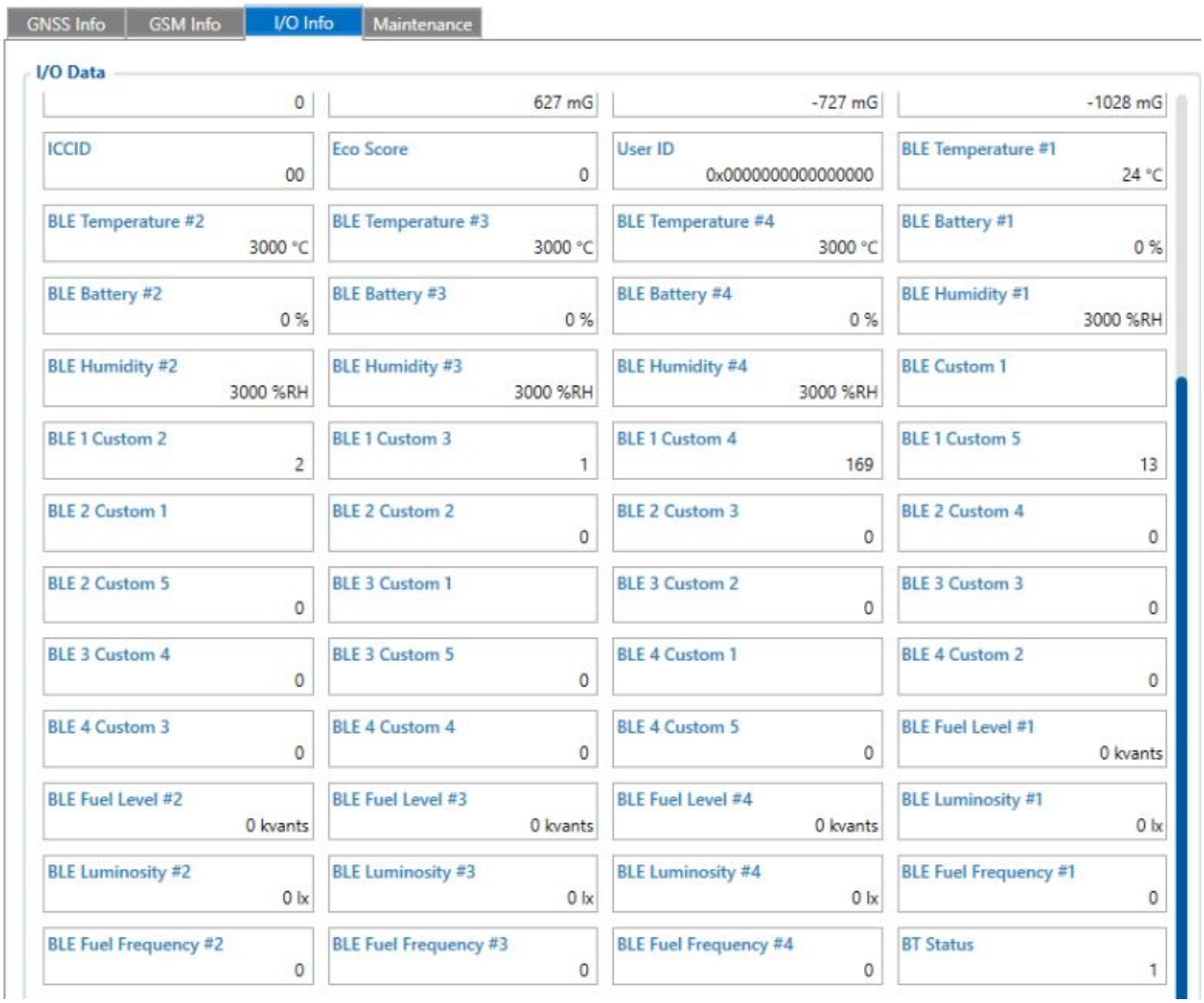
Teltonika GPS trackers should have the Advanced Bluetooth settings option (section Bluetooth 4.0 - Advanced).
Enter the following settings for reading the sensor parameters.


1st Sensor

Type	Data Offset	Data Size	Action	IO	Match	Endianess	Multiplier	Offset
ff	0	0	Save	None		Little Endian	1	0
ff	2	1	Save	Custom2		Little Endian	1	0
ff	3	1	Save	Custom3		Little Endian	1	0
ff	4	1	Save	Custom4		Little Endian	1	0
ff	5	1	Save	Custom5		Little Endian	1	0
ff	6	2	Save	Fuel Frequency		Little Endian	1	0
ff	8	2	Save	Fuel		Little Endian	1	0
ff	10	1	Save	Temperature		Little Endian	1	0
	0	0	Match	None		Little Endian	1	0
	0	0	Match	None		Little Endian	1	0

Connection #2

With these settings applied we will see the sensor data in Teltonika configurator



The meanings of these datafields (Tilt angle measurement mode):

BLE sensor 1: BLE Custom 2 - Angle X
BLE sensor 1: BLE Custom 3 - Angle Y
BLE sensor 1: BLE Custom 4 - Angle Z
BLE sensor 1: BLE Custom 5 - Sensor status (refer to the Eurosens Degree BT BLE protocol document)
BLE sensor 1: Fuel level - Number of events
BLE sensor 1: Fuel frequency - Number of complex events
BLE sensor 1: temperature – temperature

According to the Teltonika AVL ID wiki our data will have these IDs in the Teltonika protocol: https://wiki.teltonika-gps.com/view/FMB_AVL_ID

BLE sensor 1: BLE Custom 2 - Angle X **ID=463**
BLE sensor 1: BLE Custom 3 - Angle Y **ID=464**
BLE sensor 1: BLE Custom 4 - Angle Z **ID=465**
BLE sensor 1: BLE Custom 5 - Sensor status (refer to the Eurosens Degree BT BLE protocol document) **ID=466**
BLE sensor 1: Fuel level - Number of events **ID=270**
BLE sensor 1: Fuel frequency - Number of complex events **ID=306**
BLE sensor 1: temperature - temperature **ID=25**

Drum operation mode
BLE sensor 1: BLE Custom 2 - Drum operation speed (rpm) **ID=463**
BLE sensor 1: BLE Custom 3 - Angle Y **ID=464**
BLE sensor 1: BLE Custom 4 - Angle Z **ID=465**
BLE sensor 1: BLE Custom 5 - Sensor status (refer to the Eurosens Degree BT BLE protocol document) **ID=466**
BLE sensor 1: Fuel level – Drum operation time (minutes) **ID=270**
BLE sensor 1: Fuel frequency – Number of drum starts **ID=306**
BLE sensor 1: temperature - temperature **ID=25**

Boom control mode
BLE sensor 1: BLE Custom 2 - Angle X **ID=463**
BLE sensor 1: BLE Custom 3 - Angle Y **ID=464**
BLE sensor 1: BLE Custom 4 - Angle Z **ID=465**
BLE sensor 1: BLE Custom 5 - Sensor status (refer to the Eurosens Degree BT BLE protocol document) **ID=466**
BLE sensor 1: Fuel level – Current status of operation (1 – in operation, 0 – not in operation) **ID=270**
BLE sensor 1: Fuel frequency – Total operation time (minutes) **ID=306**
BLE sensor 1: temperature - temperature **ID=25**