

FSAE ITALY – Energy Meter Data Logger

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Revision History

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1 Information about EMDL for the event

During the registration phase, at the event site, the Energy Meter Data Logger (EMDL) will be delivered to the teams that have already received the badges. A 50 € deposit is required. A picture of the EMDL is present in Figure 1.

The EMDL will be checked in terms of functionality and calibration at the delivery desk, just before being delivered to the team.

The team is asked to prepare in advance all the wiring harness required to operate the EMDL:

- High Voltage negative (HV-) Battery side
- High Voltage negative (HV-) Vehicle/Inverter side
- High Voltage positive (HV+) measuring point
- Power supply (Vsup and GND) and CAN (CANH and CANL) harness
- Ethernet (TX+, TX-, RX+, RX-) harness from EMDL to an external female RJ45 connector for the inspections and for collecting logged data

The RJ45 female connector must be easily accessible without the need of removing any kind of panel and/or component (no matter if the obstacle is easily removable without any tools).

The correct installation of the EMDL in the vehicle will be checked during electrical technical inspections AND during driverless technical inspections (for driverless teams). For the functional test, the vehicle must be lifted and the driving wheels removed. Before the EMDL verification, the technical inspection is not considered complete.

The data collection from the EMDL will be performed at the end of each dynamic event, more than once if required by the inspectors. The collection of logged data can also be performed anytime on the site or at the team box. The team is responsible for constantly acquiring and checking the CAN message sent by the EMDL to verify it is correctly working and logging the data. Failure to collect data from the EMDL will bring to DSQ for that dynamic event.



Figure 1: EMDL picture

2 EMDL Datasheet

EMDL is an electronic control unit that can log data and measure energy and power in electric vehicles.

For electric vehicles category, the EMDL must be installed in the tractive system supply lines to log voltage, current, power and energy. These measures are used for the efficiency score, and to observe whether the power and voltage limitations are met.

For Driverless category, the EMDL must be installed on the vehicle CAN network to log signals listed in the CAN Bus chapter (driverless section).

In Figure 2 an overview of the EMDL is shown.

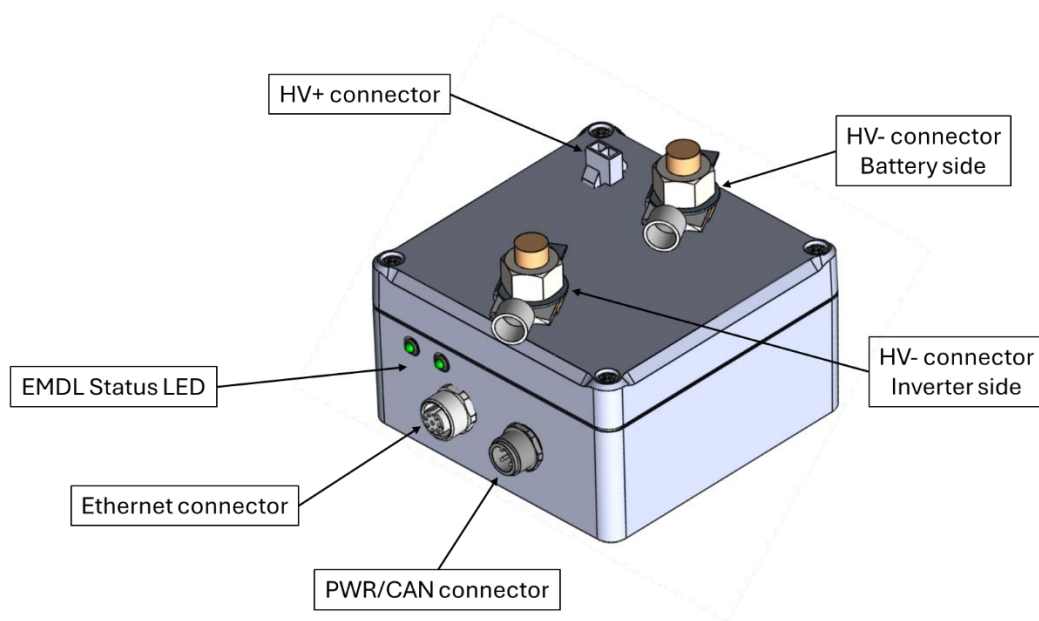


Figure 2: EMDL overview

2.1 Drawings and mechanical instructions

The EMDL dimensions are shown in Figure 3.

The EMDL weight is 552 g.

There are no constraints about the orientation for the installation in the car.

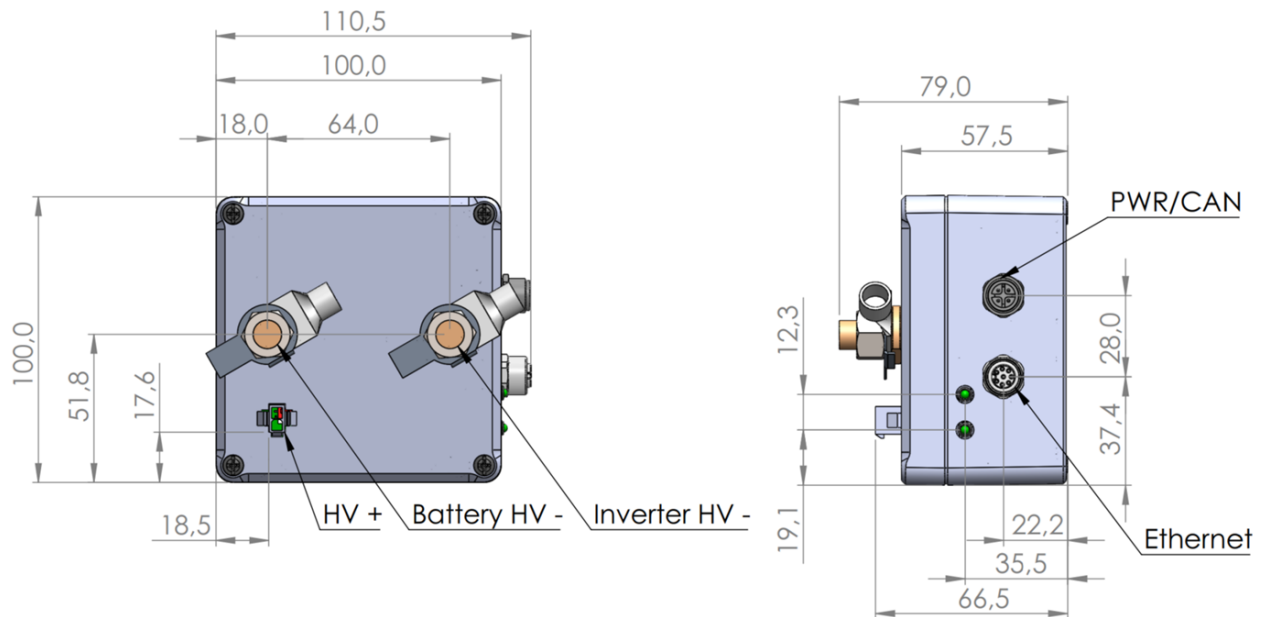


Figure 3: Mechanical drawings - 2D view

The maximum torque to tighten the nuts on the HV- power connections (Battery and Inverter) is 15 Nm. Do not exceed that threshold otherwise the EMDL could be damaged.

The positive locking mechanism for the HV- power connections is implemented by using custom washers delivered together with the EMDL. It is requested to follow the procedure described below to implement the positive locking mechanism in the right way:

1. Place the connector lug over the brass M10 x 1.25 threaded stud
2. Place the tab washer on the connector lug. The small bended tab must be aligned to the straight face of the bottom part of the threaded stud
3. Tighten the M10x1.25 nut being careful to not exceed the max torque of 15Nm.
4. Bend the long tab of the washer over a nut's face (a plier can be used to deform the tab and fit the nut)

In Figure 4 the main steps of the procedure are shown.

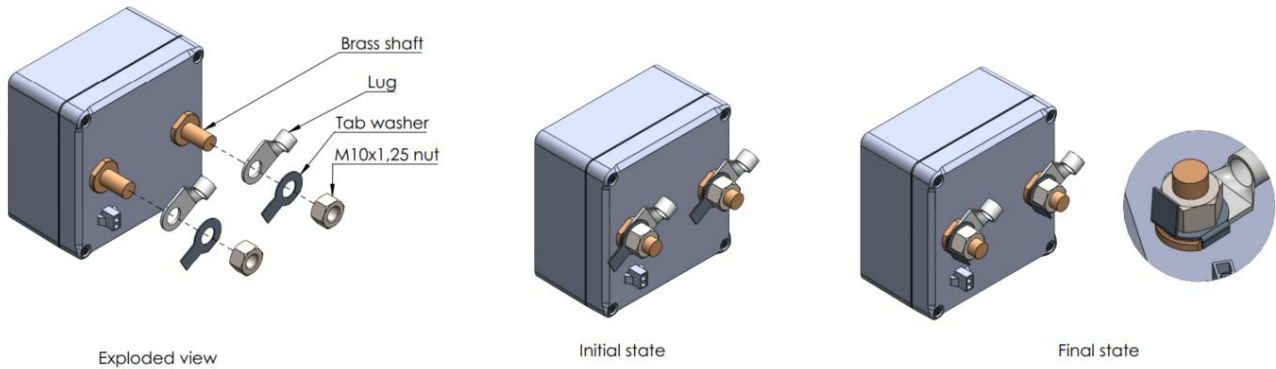


Figure 4: HV- power connection with positive locking mechanism

2.2 LEDs Behavior and Status

In this picture LED A and LED B are identified. Looking at these LEDs, visual feedback about the correctness of installation is provided. The status of the EMDL is also sent via CAN (see relative chapter).

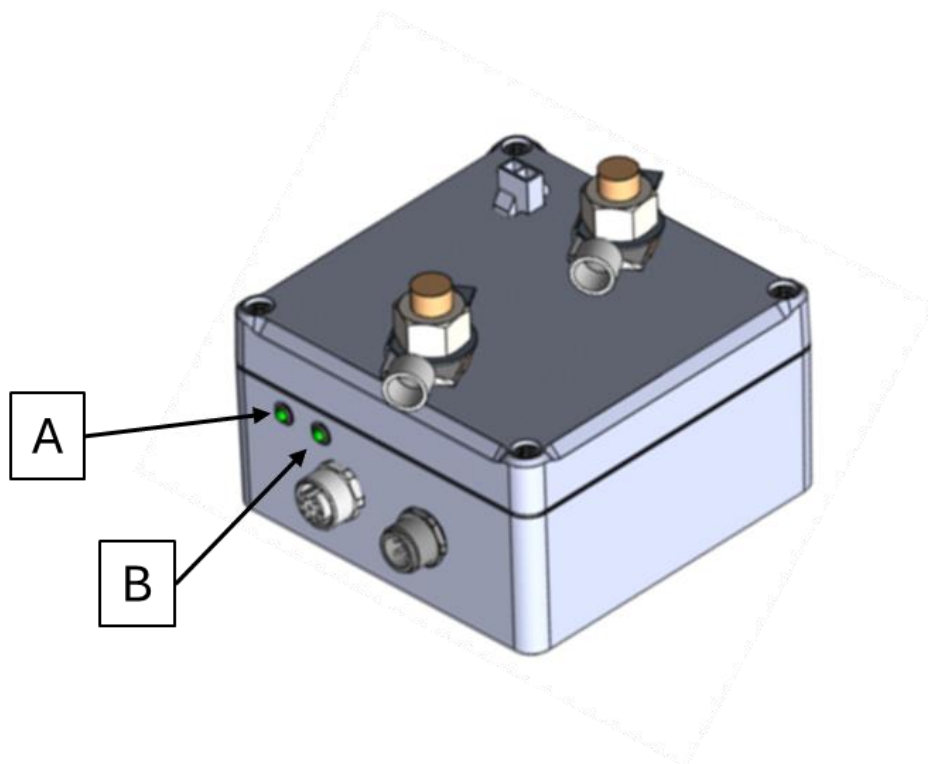


Figure 5: LEDs Identification

The following table lists the behavior of the LEDs with respect to the EMDL Status:

Status	LED A	LED B
Idle, ready to log	Steady Green	OFF
Logging	Steady Green	Slowly Blinking Green
Fault	Blinking/Steady Red or OFF	Blinking/Steady Red or OFF

2.3 Connectors Pinout

In the EMDL overview present in Figure 2 it is possible to identify five electrical connections for signal and power.

The connectors and relative pinout are described in the following sections.

2.3.1 EMDL HV connections

2.3.1.1 HV+

The HV+ connector on the EMDL is the **Molex 39-01-2026**.

The pinout is described in the table below. Both pins must be connected.

PIN	Description
1	HV Battery positive pole
2	HV Battery positive pole

The HV+ connector is located on the top side of the EMDL, as shown in Figure 6 (red circle).

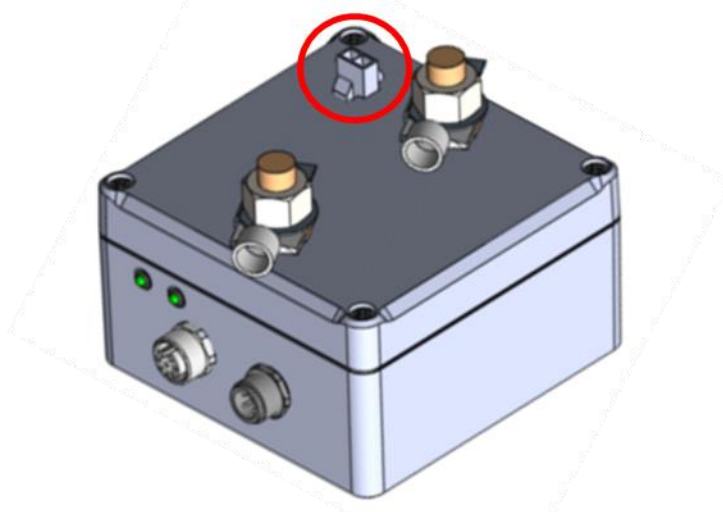


Figure 6: HV+ connector position

The team is responsible for the realization of the wiring harness to connect the HV positive pole of the HV battery to the above-mentioned connector.

2.3.1.2 HV-

On the top side of the EMDL there are two threaded studs as shown in Figure 7 (red circles). The Inverter HV- must be connected to the one on the left side, while the Battery HV- must be connected on the one on the right side (there are labels on the EMDL as an aid to avoid errors while connecting the harness).

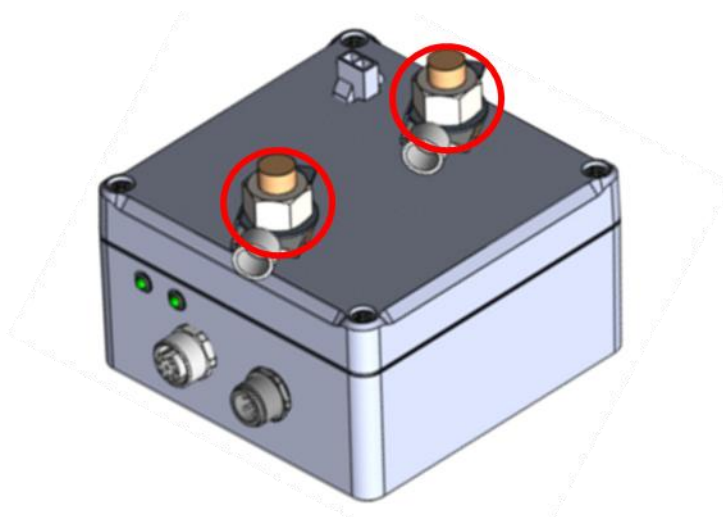


Figure 7: HV- connection - Threaded stud position

The HV- connections must be implemented according to the following instructions:

- Nut to be used: UNI 5587 M10 x 1.25 provided by the event organization
- Custom washer for positive locking provided by the event organization
- Harness terminal lug requested characteristics (example of compliant terminal lug is shown in Figure 8):
 - Max lugs contact outer diameter 18 mm
 - Max lugs thickness 1.5 mm
 - Lug p/n example: TE 160032

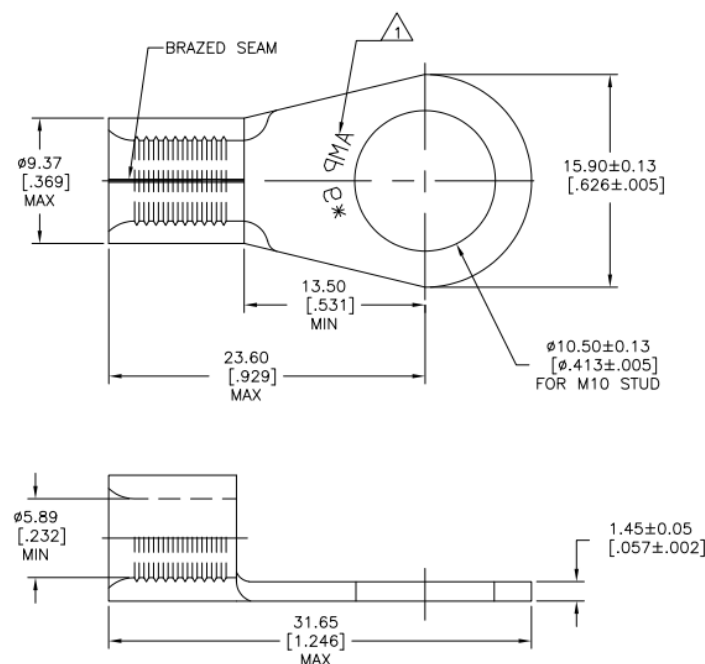


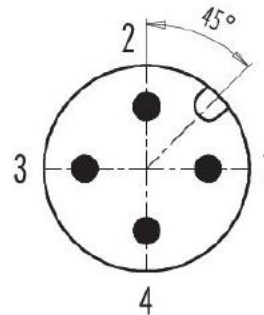
Figure 8: Terminal lug dimensions (example of compliant component)

2.3.2 EMDL Power Supply and CAN connector

The male connector for power supply and CAN on the EMDL side is **Binder 99-3431-202-04**.

The pinout is visible on the table and picture below.

PIN	Description
1	Vsup
2	GND
3	CANH
4	CANL



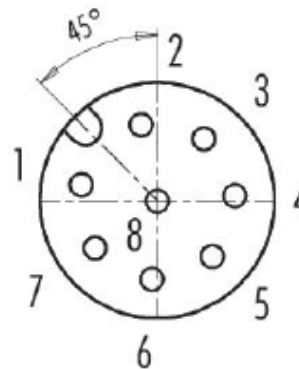
The team is responsible for the realization of the wiring harness to interface the EMDL with the low voltage battery and the CAN network. A possible female part number for the connector on the cable is **Binder 99-0430-19-04**; others are available on the market.

2.3.3 EMDL Ethernet connector

The female ethernet connector on the EMDL side is **Binder 99-3482-202-08**.

The pinout is visible on the table and picture below.

PIN	Description
1	Ethernet TX-
2	Ethernet RX+
3	Ethernet RX-
4	Reserved (leave open)
5	Reserved (leave open)
6	Reserved (leave open)
7	Ethernet TX+
8	Reserved (leave open)



The team is responsible for the realization of the wiring harness to interface the EMDL with the RJ45 female connector. A possible male part number for the connector on the cable is **Bulgin PXPPAM12FIM08ASTPG9**; others are available on the market.

2.3.4 Vehicle Female Ethernet RJ45 connector

PIN	Description
1	Ethernet TX+
2	Ethernet TX-
3	Ethernet RX+
4	-
5	-
6	Ethernet RX-
7	-
8	-



Be careful, the cable pinout from EMDL connector to RJ45 connector is NOT one-to-one!

You are almost an engineer; it is not an issue for you. 😊

2.4 Operating Conditions

Operating Temperature

- Min -40 °C
- Max +105 °C

Power Supply (Vsup)

- Min +9 V
- Max + 60 V
- Recommended $11\text{ V} < V_{\text{sup}} < 30\text{ V}$

Power Consumption

- $\sim 1.2\text{ W}$ ($9\text{ V} < V_{\text{sup}} < 30\text{ V}$)

Insulation

- Max Working Insulation Voltage
 - 1000 V RMS CATI
 - 600 V RMS CATI-II
- Basic Insulation DC Voltage 1000 V

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- Reinforced Insulation DC Voltage 600 V
 - Highest allowed transient overvoltage 6000 V (< 1 s)

Tractive System measuring Voltage

- Measuring range: ± 1000 V
- Total Accuracy < ± 0.5 %
- Extended range (nonlinear): ± 1200 V

Tractive System measuring Current

- Measuring range: ± 1000 A
- Total Accuracy < ± 0.4 %
- Extended Load:
 - ± 1400 A (< 30 s)
 - ± 2000 A (< 10 s)

3 CAN Bus

The CAN-bus protocol used by the EMDL is CAN standard 2.0B. The bitrate is fixed at **500 kbit/s**. The team is required to set this baud rate on all ECUs in this network.

The EMDL has no internal CAN termination mounted; 120 Ω termination at both ends of the bus are strongly recommended.

3.1 Electric Vehicles Message

EMDL sends a message with CAN-ID 0x430 at 20 ms of cycle time, intel format, containing the following information.

Signal	Bits	Type	Unit	Factor
MsgCntr	0-7	Unsigned	-	1
Status	8-15	Unsigned	-	1
Power	16-31	Signed	W	3 W / bit
Voltage	32-47	Signed	V	0.04 V / bit
Current	48-63	Signed	A	0.05 A / bit

- **MsgCntr** signal is a rolling counter of 8 bits (0-255). The team should check that this counter is increasing, and no message is lost nor EMDL is stuck on the same value.
- **Status** informs the vehicle of the functionality of the EMDL:
 - 0x1 – EMDL idle, ready to log
 - 0x3 – Logging Electric data
 - 0x5 – Logging Driverless data
 - 0x7 – Logging Electric and Driverless data
 - 0x8 – Fault

A CAN database including this message is available (EMDL_Status_v1.1.dbc)

3.2 Driverless Messages

Driverless teams must provide the EMDL with all the signals listed in the following messages.

Messages 0x500 and 0x502 are mandatory (missing values must be interpolated or calculated), while message 0x501 depends on the sensors available on the vehicle.

All messages have a cycle time of 100 ms and Intel format signals.

A CAN database including these messages is available as an example (EMDL_DV_v1.1.dbc)

The steering angle δ and the vehicle definitions are shown in the figure below.

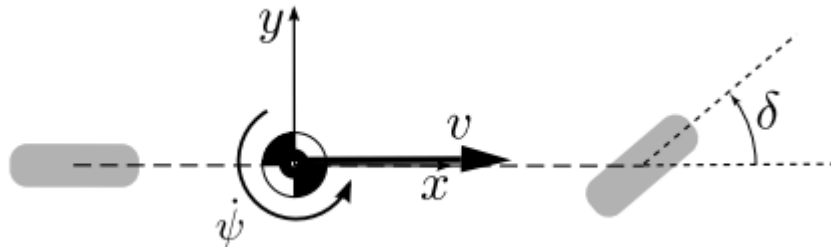


Figure 9: Steering angle δ and vehicle coordinates definition

3.2.1 CAN-ID 0x500

DLC: 8 Bytes

Cycle time: 100 ms

Signal	Bits	Type	Unit	Factor
Speed_actual	0-7	Unsigned	$\frac{km}{h}$	1
Speed_target	8-15	Unsigned	$\frac{km}{h}$	1
Steering_angle_actual	16-23	Signed	°	0.5
Steering_angle_target	24-31	Signed	°	0.5
Brake_hydr_actual	32-39	Unsigned	%	1
Brake_hydr_target	40-47	Unsigned	%	1
Motor_moment_actual	48-55	Signed	%	1
Motor_moment_target	56-63	Signed	%	1

3.2.2 CAN-ID 0x501

DLC: 6 Bytes

Cycle time: 100 ms

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Signal	Bits	Type	Unit	Factor
Acceleration_longitudinal	0-15	Signed	$\frac{m}{s^2}$	$\frac{1}{512}$
Acceleration_lateral	16-31	Signed	$\frac{m}{s^2}$	$\frac{1}{512}$
Yaw_rate	32-47	Signed	$\frac{m}{s^2}$	$\frac{1}{128}$

3.2.3 CAN-ID 0x502

DLC: 5 Bytes

Cycle time: 100 ms

Signal	Bits	Type	Unit	Factor
AS_state	0-2	Unsigned 1: off 2: ready 3: driving 4: emergency 5: finished	-	1
ASB_EBS_state	3-4	Unsigned 1: deactivated 2: initial_checkup_passed 3: activated	-	1
AMI_state	5-7	Unsigned 1: acceleration 2: skidpad 3: trackdrive 4: braketest 5: inspection 6: autocross	-	1

Steering_state	8	Unsigned	bool	1
ASB_redundancy_state	9-10	Unsigned 1: deactivated 2: engaged 3: initial_checkup_passed		
Lap_counter	11-14	Unsigned	-	1
Cones_count_actual	15-22	Unsigned	-	1
Cones_count_all	23-39	Unsigned	-	1

3.2.4 ASF Messages CAN-ID 0x511-0x515

All signals that are present in the ASF (Autonomous System Form) must be sent as signals in one or more messages, with CAN-ID ranging from 0x511 to 0x515.

Each of the five messages, if sent, must have:

- DLC: of up to 8 Bytes
- Cycle time: 100 ms