Mobileye Startup Guide

Version: 1.6
9/2/15

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1 Overview

- Mobileye is a private company, founded in 1999, in Israel.
- Largest automotive vision-based research center in the world, located in Israel.
- Offices in the US, Japan, the Netherlands, and Cyprus.
- Our technology is marketed either as a chip integrated into the existing systems produced by automobile manufacturers (OEMs) or as stand-alone aftermarket products.
- We work with the major automotive manufacturers worldwide:
- The Mobileye 5-Series uses a single-camera-based safety solution for collision prevention and mitigation.
- A smart camera, mounted on the interior side of the windshield, utilizes Mobileye's pedestrian, vehicle, lane and traffic sign detection technologies to measure the distance to pedestrians, bicyclists, vehicles and lane markings, providing the driver with timely and often life-saving alerts.

1.1 The Mobileye Technology

The Mobileye 5 system uses a smart digital camera located on the front windshield inside the vehicle. Inside the camera, Mobileye's powerful EyeQ2® Image Processing Chip provides high-performance real-time image processing, by utilizing the Mobileye vehicle, lane and pedestrian detection technologies to effectively measure and calculate dynamic distances between the vehicle and road objects. The EyeQ2 Image Processing Chip identifies and sorts the processed images into real-life driving situations, and transmits relevant alerts to the EyeWatch® display and control unit, providing the driver with life-saving alerts.

1.2 Safety

- Mobileye 5 does not guarantee 100% accuracy in the detection of vehicles or driving lanes, nor in providing warnings of all potential road hazards.
- Mobileye 5 does not see any better than the driver, and it is still the driver's responsibility to always be alert and depend on his own eyesight.
- Driving Conditions - Road - Mobileye 5 is intended for paved roads with clear lane markings. While driving on an unpaved road or off road, all system features might be adversely affected.
- Weather - Mobileye 5 does work in diverse weather conditions, but extreme weather conditions that drastically affect visibility might adversely affect the system's features response capabilities.
- Camera – All the features are dependent on the camera's field of view! Always ensure the camera has a clear field of view! All the features are dependent on proper camera calibration performed by you.
- PCW (Pedestrian Collision Warning) -
    - PCW is active only during daylight hours. At night PCW is automatically disabled!
    - PCW is available only in certain geographical areas.
    - PCW is available only on certain Mobileye 5 modules.

1.3 The System's Features - Alert Types

The Mobileye 5-Series uses a single-camera-based safety solution for collision prevention and mitigation.
A smart camera, mounted on the interior side of the windshield, utilizes Mobileye's pedestrian, vehicle, lane and traffic sign detection technologies to measure the distance to pedestrians, bicyclists, vehicles and lane markings, providing the driver with timely and often life-saving alerts.

The Mobileye 5-Series also utilizes Bluetooth wireless technology, enabling to receive all Mobileye alerts straight to the driver's private Smartphone.

Mobileye Collision Prevention Systems are the only ones offering essential multi feature collision prevention alerts in one unit!

The Mobileye 5 features contribute to:

- Collision prevention and mitigation
- Enhanced driver alertness and improved driving habits
- Driver Behavior Analysis (when integrated with Fleet Management Systems)

1.3.1 FCW - Forward Collision Warning

FCW Alerts the driver of an imminent rear end collision with a vehicle or motorcycle in front of him. Studies show that 1.5 seconds of early warning can prevent almost 90% of all rear-ends collisions. FCW alerts the driver up to 2.7 seconds before a collision occurs, allowing enough time to react.

- As long as the system is turned on, FCW is active.
- Speed – FCW operates when the vehicle is operating at 30-200 Km/h (18-124 Mph).
- At slower speeds, Urban FCW operates (This is the next feature).

1.3.2 UFCW – Urban Forward Collision Warning

UFCW works exactly like FCW, but is configured to operate at slow speeds typical to urban driving and dense traffic conditions. The UFCW acts like a virtual front bumper whose depth can be adjusted.

- As long as the system is turned on, UFCW is active.
- Speed – UFCW operates when the vehicle is operating at 0-30 Km/h (0-18 Mph).

1.3.3 PCW - Pedestrian Collision Warning

PCW alerts the driver of an imminent collision with a pedestrian or a cyclist ahead. The system issues a warning a maximum of 2 seconds before a possible collision takes place, allowing the driver enough time to react.

- As long as the system is turned on, PCW is active during daylight hours.
- At night PCW is automatically disabled!
- Speed – PCW operates when the vehicle is traveling at less than 50 Km/h (31 Mph).
- A Red pedestrian icon flashing with no Audio alert indicated that there is a pedestrian in the vehicle's Danger Zone* but collision time is greater than 2 sec.

1.3.4 LDW – Lane Departure Warning

LDW alerts the driver when deviating unintentionally from the driving lane. The system measures the distance from the vehicle's wheels to the lane markings on both sides and issues an alert when deviation occurs.

- As long as the system is turned on, LDW is active.
- Speed – LDW operates when the vehicle speed is above 55 Km/h (34 Mph).
- LDW will not issue an alert in the following situations:
  - If the driver signals by using the blinkers.
  - If the lanes are poorly marked or completely unmarked.
  - During a sharp turn (such as exiting a highway).
  - After an LDW alert has been issued, until the vehicle returns to the center of the lane (30cm/12inch back from the lane marking).

The Adaptive LDW Width **requires no configuration** from the installer or from the user. Adaptive LDW Width is depended on the LDW sensitivity setting level.

If LDW sensitivity setting is set to level "0" – No LDW
If LDW sensitivity setting is set to level "1" or "2" – the LDW alert will function normally with additional Adaptive LDW Width feature described below.

Narrow Lane
If the Lane Width is smaller than the Vehicle Width (front wheelbase) + 15%, then the LDW will be automatically **disabled** (until the lane width increases to normal values).
Acceptable Lane
If the Lane Width is greater than the Vehicle Width (front wheelbase) +15%, but smaller than the Vehicle Width (front wheelbase) +30%, then LDW alert will be **late** (meaning LDW alert will sound after the lane crossing).
Standard Lane
If the Lane Width is greater than the Vehicle Width (front wheelbase) +30%, then the LDW feature will function **normally**

1.3.5 HMW – Headway Monitoring Warning

HMW assists the driver in keeping a safe driving distance from the vehicle in front of him, by issuing an alert when the headway distance to the vehicle ahead becomes dangerous. Drivers very often overestimate the distance to the vehicle ahead, not realizing that as their speed increases, the available reaction time decreases. HMW displays the distance to the current position of the vehicle in front and issues an alert if the distance is lower or equal to a pre-defined threshold. The Headway distance is measured and displayed in time (seconds) and not in meters. Headway is the number of seconds it would take for your vehicle to reach the current position of the vehicle ahead. Headway is NOT the Time to collision.

- As long as the system is turned on, HMW is active.
- Speed – HMW operates when the vehicle speed is above 30 Km/h (18 Mph).
- HMW will not issue an alert after an HMW alert has been issued, until the vehicle returns to the headway distance of at least 1/2 of the pre-defined threshold.

1.3.6 IHC – Intelligent High-Beam Control

Mobileye Intelligent High-Beam Control controls a vehicle's head lights by automatically switching them from low beam to high beam on dark roads without nearby traffic.

WHEN IS MOBILEYE IHC FUNCTIONAL?

- Mobileye IHC is active at night, on dark roads (with no street lights), without nearby traffic.
- Mobileye IHC is active at speeds greater than 35 km/h (21 mph).
- Mobileye IHC is active only if enabled.

MOBILEYE IHC WILL NOT SWITCH TO HIGH BEAMS WHEN:

- Another vehicle's tail lights are detected in front of your vehicle at a distance of less than 400 meters (0.25 mile).
- There is an oncoming vehicle at a distance of less than 800 (0.5 mile) meters.
- Your vehicle enters a well-lit area, or street lights are detected.

IMPORTANT NOTES:

1. Mobileye IHC is available only on selected vehicle models.
2. Mobileye IHC is available only if activated during system installation.
3. Mobileye IHC is available only in certain geographical areas

1.3.7 SLI and TSR – Speed Limit Indication and Traffic Sign Recognition

Detects and classifies various speed signs and notifies the driver if the vehicle's speed exceeds the allowed speed detected on the sign. Speed limit Indication (SLI) and Traffic Sign Recognition (TSR) is available only via Mobileye Smartphone application.

1.3.8 LKA – Lane Keeping and Guidance Assist

The lane keeping application actively applies torque to the steering wheel, to prevent and unintentional drift of the vehicle out of the lane. Mobileye supplies information on the lane boundary geometry to the vehicle steering system. Based on the lane boundary geometry, the steering system decides if a torque needs to be applied, and if so to what extent. The outcome is a gentle steering which prevents the vehicle to veer off the lane. Mobileye has already supported a number of successful lane keeping production programs with OEMs.

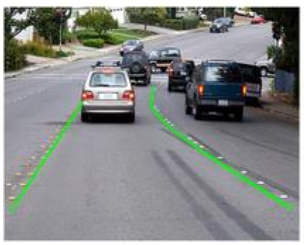
1.4 Detections

1.4.1 Vehicle Detection

- Detection of square and rectangular elements at the vehicles' rear.
- Detection of the back wheels.
- Detection of rear lights at night.
-

1.4.2 Lane Detection

- Detection of solid or dashed lane markings.
- Detection of continuous road markings.



1.4.3 Pedestrian Detection

- Detection of human body characteristics.
- Detection of walking motion.

2 Components

2.1 Mobileye 5 Main Unit - camera

- ***Camera unit–***
  - Day / Night compatible.
  - View field of 40° X 30° (Width X Height).
  - Typical vehicle detection range: 80m (262 ft.).

  Note!
  - The camera should always have a clear field of view!
  - The camera should be calibrated once by the authorized installer to assure proper functionality.
  - Never open the camera assembly!

- Mobileye Chip on Board system - "***EyeQ2***" Image Processing Chip – Real-time image processing at 15 FPS.

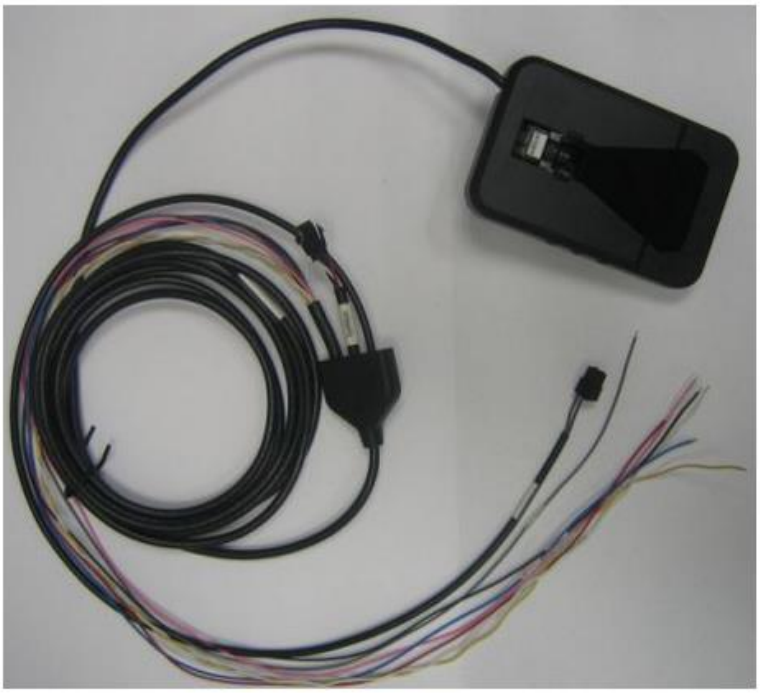
- ***High Quality Integrated speaker*** (Audio Alert Buzzer)
- ***Blue L.E.D*** - indicates that the VSU is receiving power.
- ***System Volume Buttons***.
- ***Connector Cable***

2.2 Mobileye 5 Main unit Connector cable (CAB000105)

The Mobileye 5 Connector cable is split into a few various wires which are used for connection with the following:

- The vehicle power source wires
- The vehicle CAN-bus wires
- The vehicle High-beams (for IHC) via external Relay
- The Mobileye EyeWatch Display & Control unit
- The Mobileye EyeCAN cable for system configurations.

Wire Name & Function	Wire color	Connection To
BAT+ (12/24V)	Red	Vehicle constant power (Battery)
GND	Black	Vehicle GND (BAT-)
Ignition (12/24V)	Blue	Vehicle Ignition signal
CAN B H	White	Vehicle CAN-bus (CAN High wire)
CAN B L	Yellow	Vehicle CAN-bus (CAN Low wire)
IHC – (Analog Output)	Gray	Vehicle High-beams via external Relay
AUX	Pink	AUX - 1 analog signal (except Speed Signal)
EyeCAN - (6 pin connector)	Black	EyeCAN unit (for system calibration)
EyeWatch - (4 pin connector)	Black	EyeWatch Display & Control unit



EyeCAN Pin Out	
Vision CAN High	Brown
Vision CAN Low	Purple

2.3 EyeWatch Display & Control unit (CAB000087)

- The EyeWatch is connected to the Mobileye 5 Main unit connector cable using the only 4 pin connector available.
- The EyeWatch Display and Control Unit are sold as an optional add-on on certain Mobileye 5 models.
- Mobileye 5 can also be used with both Android and IOS (Apple IPhone) based Bluetooth device (Smart Phone) for displaying Mobileye 5 Alerts.

- Display – Displays all of the visual alerts and indications to the driver.

- Control Buttons - “ **+** ”, “ **-** “ and

  (menu):
  - Power On / Off
  - System volume adjustment
  - Display brightness adjustment
  - Features sensitivity adjustment (read the EyeWatch operational instructions)

- Attachment Clip – Fastens the EyeWatch in its place.

Caution!
After powering up the system - do not press the EyeWatch buttons before you learn how to adjust each feature!

2.4 External Fuse Holder

The Mobileye 5 is supplied with an External Fuse Holder and a 2A Fuse for protection against short circuiting the vehicle electrical system.

The External Fuse Holder connection is as follows:

1. Cut the fuse holder cable so that it creates 2 separate wires
2. Connect one end of the Fuse holder to the Vehicle Power source (12V/24V).
3. Connect one end of the Fuse wire to the Mobileye Power Cable (Red wire).

3 Software Installation

The Mobileye calibration and testing application requires two Microsoft® applications in order to function properly:

".NET Framework 3.5™ "and "SQL Server 2005 Express Edition® ".

3.1 System Requirements

We do not recommend using netbooks or other small form factor laptops equipped with 10" screens for compatibility reasons!

Before installing the applications and software, make sure your laptop computer meets the minimum system requirements described here:

Operating System:
Windows XP® with SP3 installed or Windows 7®

Make sure your Windows installation supports standard Latin / Cyrillic formats (relevant for Asian users).
The Mobileye software support 32/64 bit operating systems.

Processor Speed:
Minimum: 600 MHz Pentium® or equivalent
Recommended: 1GHz Pentium® or equivalent

Memory (RAM):
Minimum: 512 MB
Recommended: 1 GB or more

Hard Drive Free Space:
Minimum: 500 MB of available hard-disk space

Recommended Screen Resolution:
1152 X 486 or 1024 X 768 or 1280 X 960

Recommended Screen DPI:
96

Privileges:
Make sure you have Administrator Privileges.
If you do not have Administrator Privileges contact your IT department for assistance.

3.2 Before Installing Mobileye Software

3.2.1 Installing Microsoft .NET Framework 3.5

Verify you do not have Microsoft .NET Framework 3.5 installed already by following the next steps:

Only for Windows XP users! Not required for Windows 7!

- Click the “Start” button.
- Click "Settings" and then click "Control Panel".
- Click "Add or Remove Programs".
- Try to locate "Microsoft .NET Framework 3.5" in the programs list.
  - If it is in the list – skip this installation and proceed to "Installing Microsoft SQL Server 2005 Express Edition".
  - If you do not have "Microsoft .NET Framework 3.5" in the list, or you have any version other than version 3.5 – continue with this installation.

Follow the instructions to install Microsoft .NET Framework 3.5

Link to download

ftp://ftpclient.mobileye.com/AWS/technical_files/AWS%20Setup%20Wizard/dotnetfx35.exe

When a window pops-up click "Run".

3.2.2 Installing Microsoft SQL Server® 2005 Express Edition (SP3)

Verify you do not have Microsoft Microsoft SQL Server 2005 installed already by following the next steps:

- Click the “Start” button.
- Click "Settings" and then click "Control Panel".
- Click "Add or Remove Programs".
- Try to locate "Microsoft SQL Server 2005" in the programs list.
  - If it is in the list – skip this installation and proceed to "Installing Mobileye Setup Wizard application".
  - If you do not have "Microsoft SQL Server 2005" in the list – continue with this installation.

Follow the instructions to install Microsoft SQL Server 2005 Express Edition.

Link to download

ftp://ftpclient.mobileye.com/AWS/technical_files/AWS%20Setup%20Wizard/SQLEXPR.EXE

When a window pops-up click "Run".

3.3 Installing Mobileye Software

3.3.1 Installing the Mobileye Setup Wizard application

Please make sure again that you are connected to the Internet in order to download, install, and update the software!

Click the link to download the Mobileye Setup Wizard application from the Mobileye FTP Server.
ftp://ftpclient.mobileye.com/AWS/technical_files/AWS%20Setup%20Wizard/Mobileye_Setup_Wizard.exe
When a window pops-up click "Run".

Follow the instructions to install the Mobileye Setup Wizard application

Note:

- During the Mobileye Setup Wizard application installation various drivers are installed.You may be asked to approve their installation. Click yes or Ok to allow all Drivers to be installed.
- During the Mobileye Setup Wizard application installation the Mobileye CANsee application (used for CAN Sniffing) is installed automatically and a short cut to the application is created on your Desktop.

3.3.1.1 Keeping the Mobileye Setup Wizard application and the Vehicle Database Updated

To Update the Mobileye Setup Wizard application:

- Connect to the Internet.
- Run the Mobileye Setup Wizard application (Shortcut icon on the desktop).
- The Mobileye Setup Wizard application automatically identifies the Internet connection, checks for available updates, and
- Installs them.
- If a newer version is available, it will be automatically downloaded and you will be asked to run the new installation.
- Install the new version exactly as you did with the Mobileye Setup Wizard application.

To Update the Vehicle Database:

- Run the Mobileye Setup Wizard application (Shortcut icon on the desktop).
- Click "Next >".
- Click "Update Database" (The "Mobileye Database Sync" window will open).
- To update the database - Click "Next >".

OR

- To download the complete database file, clear the "Download database change
  Only" checkbox and click "Next".

4 Mobileye Installation

The following components are needed only for the Installation and Calibration Procedures and are not part of the Mobileye 5 kit:

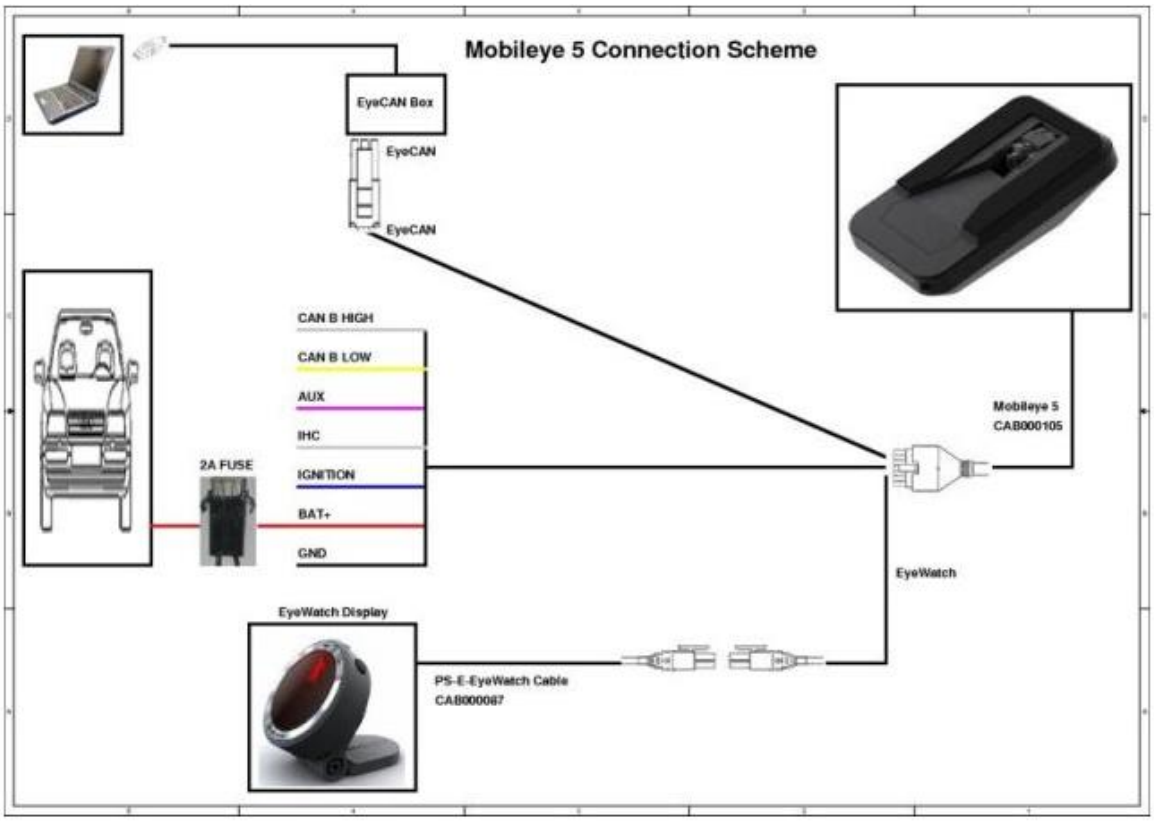
1. EyeCAN Cable kit (ICAN000001) or Kvaser Cable and Mobileye 5 kvaser adapter cable
   (CAB000115)
2. Laptop Computer with our software pack installed
3. TAC (Target for Automatic Calibration) - Optional

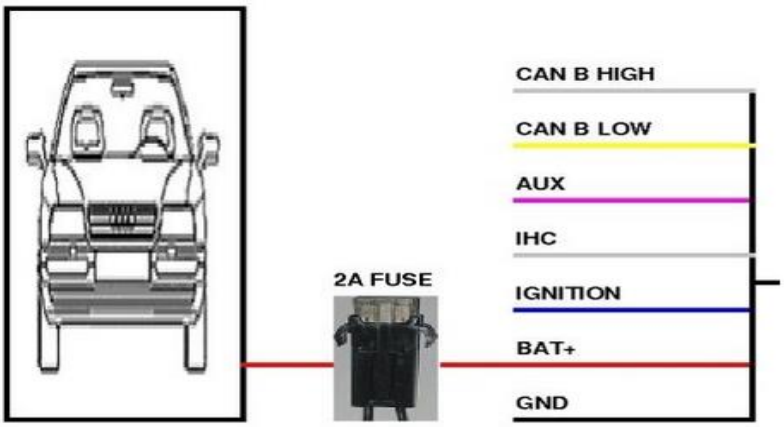
NOTE Before Starting:

- Mobileye 5 installation is possible only on CAN-bus supported vehicles.
- Full analog installation is available when using E-box.
- Minimum CAN-bus signals required for Mobileye 5 installation: Speed
- For best system performance, Mobileye recommends all signals are available over CAN-bus.
- Always check the Mobileye Vehicle Database for CAN-Bus availability before starting the installation.

4.1 Connecting to Vehicle Signals

4.1.1 Components Connection Scheme





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4.1.2 Identifying the signals

Identify the wires in the vehicle that carry the required electrical signals.

Identified vehicle signal	Wire label	Wire color
Vehicle battery (Constant 12V~24V) via 2A Fuse	BAT+	Red
Ignition (12V~24V)	Ignition	Blue
Vehicle GND	GND	Black
CAN High	CAN High	White
CAN low	CAN low	Yellow

NOTE: Keep the Mobileye 5 EyeCAN and EyeWatch connectors easily accessible.

NOTE: Make sure the 2A fuse is kept easily accessible

NOTE: Wires colors are not guaranteed. Always refer to the wires labels

CAUTION: Identifying the vehicle's electrical signals requires having the keys in the ignition in the ACC (Accessory) position or Ignition ON.

Make sure the car headlights and/or any other power consuming devices are turned off during Mobileye 5 installation to prevent battery drainage.

4.1.3 Power connections

Connects the Mobileye 5 Main unit to the vehicle's power cables using the 3 power connection wires in the Mobileye 5 connector cable:

- Constant power: 12v-24v (+30) Red wire (via 2A Fuse)
- Ignition: 12v-24v (+15) Blue wire
- Ground: GND - Black wire

NOTE: Make sure the 2A fuse is kept easily accessible

NOTE: Wires' colors are not guaranteed. Always refer to the wires' labels

CAUTION: Identifying the vehicle's electrical signals requires having the keys in the ignition in the ACC (Accessory) position or Ignition ON.

Make sure the car headlights and/or any other power consuming devices are turned off during Mobileye 5 installation to prevent battery drainage.

4.1.4 CAN-Bus connections

Connects the Mobileye 5 Main unit to the vehicle's CAN-bus wires (CAN-High, CAN-Low) using the 2 CAN-Bus connection wires in the Mobileye 5 connector cable:

- CAN High White wire
- CAN Low Yellow wire

NOTE: Make sure the 2A fuse is kept easily accessible

NOTE: Wires' colors are not guaranteed. Always refer to the wires' labels

CAUTION: Identifying the vehicle's electrical signals requires having the keys in the ignition in the ACC (Accessory) position or Ignition ON.

Make sure the car headlights and/or any other power consuming devices are turned off during Mobileye 5 installation to prevent battery drainage.

4.1.5 IHC connections

For IHC see IHC Manual

4.1.6 AUX connections

The AUX wire connects the Mobileye 5 Main unit to any of the vehicle's analog signals which is required in order to complete the Mobileye 5 installation (except Speed signal).

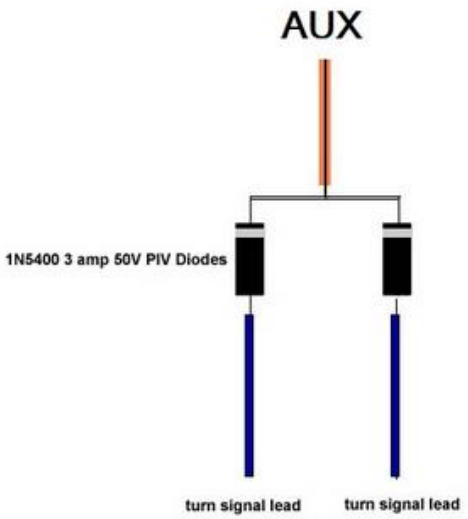
Possible signals that the AUX wire can be connected to:

- Left Turn indicator*
- Right Turn indicator*
- High Beams (analog)
- Wipers signal
- Brake light signal

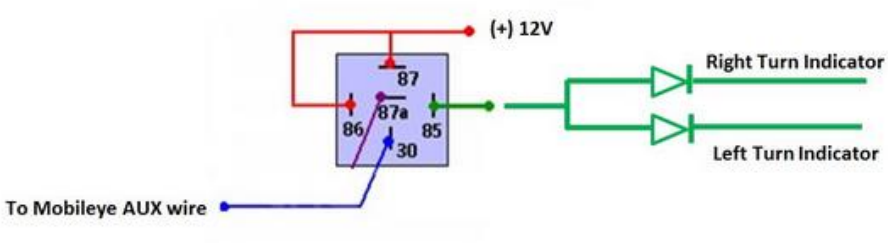
- AUX Pink wire

* The AUX wire can be connected to both Left and Right Turn indicators using 2 diodes to split the turn signal to L&R and this allow the system to receive both signals.

Option 1 - Left & right indicators are in **High** polarity



Option 2 - *Left & right indicators are in* ***Low*** *polarity*



NOTE: Make sure the 2A fuse is kept easily accessible

NOTE: Wires colors are not guaranteed. Always refer to the wires labels

CAUTION: Identifying the vehicle's electrical signals requires having the key in the ignition in the ACC (Accessory) position or Ignition ON.

Make sure the car headlights and/or any other power consuming devices are turned off during Mobileye 5 installation to prevent battery drainage.

4.1.7 Routing the camera cable

After identifying the required signals locations in the vehicle, pass the Mobileye 5 cable (CAB000105) behind the vehicle trimmings so that it reaches all vehicle signals.

It is recommended to hang the Mobileye 5 Main Unit on the rear view mirror or place it on the dashboard before passing the cable behind the vehicle trimmings.

4.1.8 Connections

Firmly connect the appropriate wire from the Mobileye 5 (CAB000105) to the identified vehicle signal.

Identified vehicle signal	Wire label	Wire color
Vehicle battery (Constant 12V~24V) via 2A Fuse	BAT+	Red
Ignition (12V~24V)	Ignition	Blue
Vehicle GND	GND	Black
CAN High	CAN High	White
CAN low	CAN low	Yellow
IHC – (Analog Output)	IHC	Gray
AUX	AUX	Pink

4.2 Installing EyeWatch (Optional)

1. Select the optimal location for the EyeWatch. The unit should be placed on the dashboard at a location which is in the driver's field of view and convenient for him to see when driving, and to allow him access to the controls while seating comfortably in the driver's seat (the EyeWatch mounting angle is adjustable by the installer, a Philips screw driver is required).

2. Clean the selected location with the provided 3M VHB Surface cleaner.

3. Attach the EyeWatch to the selected area (remove the adhesive tape's protective cover)

4. Remove the display surface's transparent protecting cover.

5. Insert the EyeWatch cable (CAB000087) behind the vehicle trimmings so that it reaches
The EyeWatch connector of the Mobileye 5 cable (CAB000105)

WARNINGS!

The EyeWatch and Main Unit should be placed in a location that does not obstruct the driver’s field of view.

The EyeWatch should not be placed in front of air-bags operational space. The unit may prevent the air-bag from fully opening and/or may cause injury during air-bag activation.

Attaching the EyeWatch on the Vehicle’s windshield is not recommended (EyeWatch may overheat).

4.3 Installing the Mobileye 5 Camera unit to windshield

1. Before starting the Camera installation, make sure that the car is not loaded with unusual heavy cargo that can tilt the orientation of the car body.

2. Make sure the vehicle is standing on a flat surface with no side or forward slope.

3. Select the optimal location for the Main Unit.

4. Please comply with the following requirements as incorrect positioning may affect the overall performance of the system:
    a. Preferably in the center of the windshield.
    b. In the windshield area covered by the wipers.
    c. In passenger vehicles – Preferably at a height of at least 1.2 meters (3.9 Ft.) above ground level.
    d. In commercial vehicles with no engine hood – At the bottom of the windshield.

5. Clean the intended Camera location on the windshield using the 3M VHB Surface Cleaner to remove oily or other remains.

6. Wipe the installation area on the windshield by thoroughly using a dry wipe (important since the 3M VHB Surface Cleaner that removes oily substances may leave marks on the windshield that will obstruct the camera's field of view)

    Note: do not attach camera at this time.

4.4 Connecting to Mobileye 5

1. Connect the Mobileye 5 EyeCAN cable (6 pin male connector – CAB000105) to the EyeCAN Unit (6 pin Female connector labeled "CAN").

2. Connect the EyeCAN unit USB connector to the Laptop Computer USB port.

3. Power On the laptop computer.

4. Power on the Mobileye 5 system by turning on the vehicle ignition switch to ACC (Accessory) position.

5. Run the Mobileye Setup Wizard Application

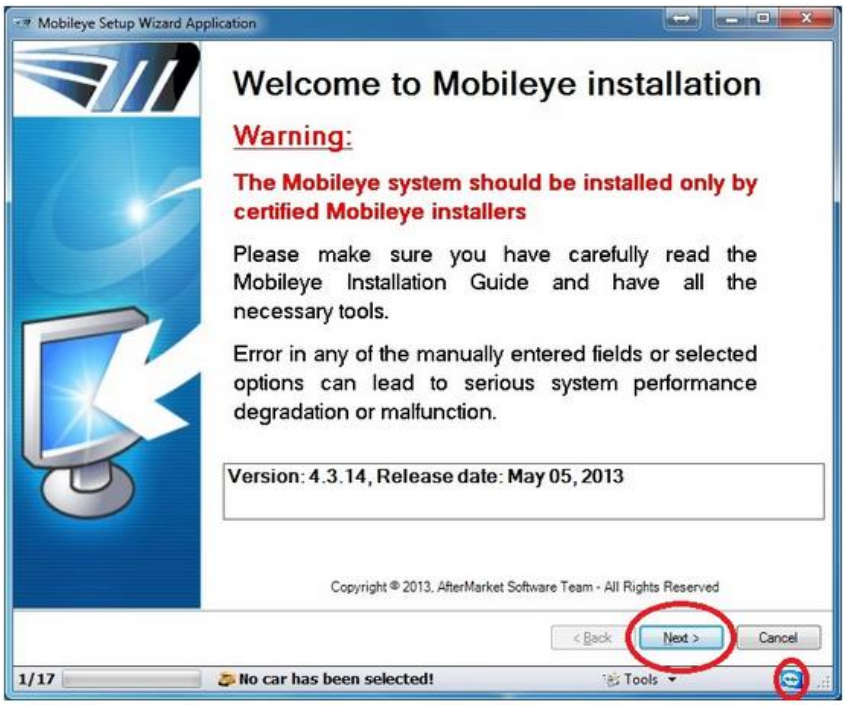
Note: If using a Kvaser cable (CAN to USB interface) an additional adapter cable will be required. This cable can be ordered from Mobileye. Cable details: Mobileye 5 Kvaser adapter cable (CAB000115)

4.5 Activating the Mobileye Setup Wizard for Camera Installation

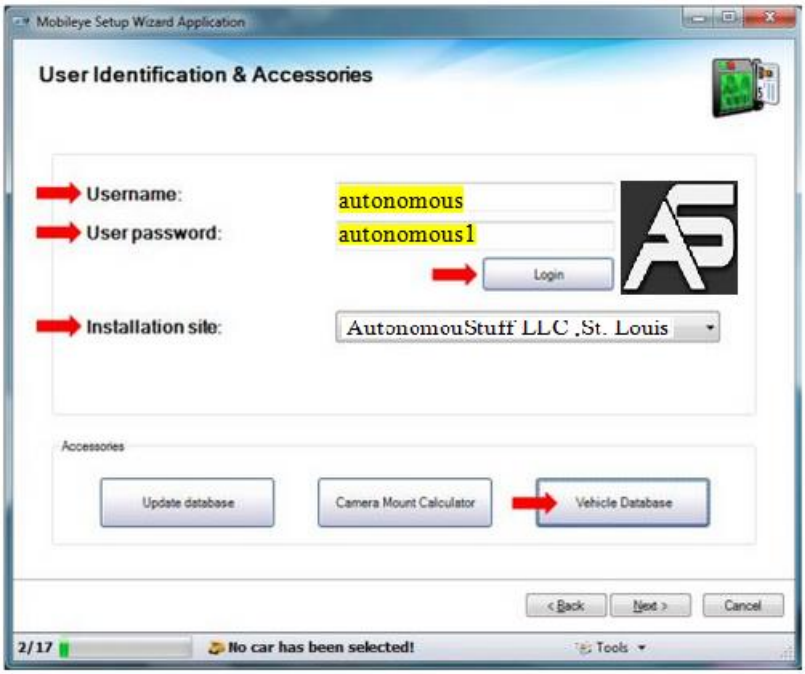
Start Mobileye Setup Wizard

1. (Screen 1/17 – Welcome Screen) this is the Mobileye Setup Wizard application welcome screen.

- Click “Next >” to continue.



2. (Screen 2/17 – User Identification and Accessories)
    - Enter the username **(autonomous)** and the password **(autonomous1)** and click "Login".
    - Select your installation site. **(AutonomouStuff St. Louis)**
    - Click on "Vehicle Database" to choose the wanted vehicle profile for the installation (remember - Mobileye5 requires at the minimum to have a Speed Signal available over vehicle CAN-bus)

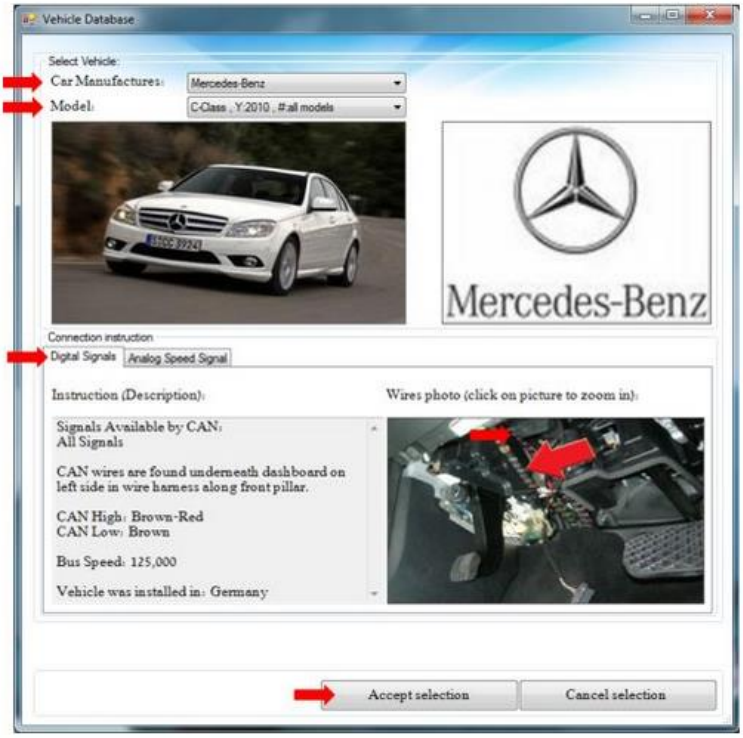


Note: In the “Accessories” pane you have three buttons:

- Update database – A link to the Mobileye Vehicle database update screen.
- Camera Mount Calculator – A link to the camera mount calculator.
- Vehicle Database – A link to the Mobileye Vehicle database.

3. (Vehicle Database - popup window) On the top of the window, select the car manufacturer and model.

- Look on the lower pane, on the "Digital Signals" tab.
- Here you can find the CAN-bus signals data, which includes all or some of the following data:
- The signals available by CAN-bus
- Location of the CAN-bus cables in the vehicle
- Color of the CAN-bus cables
- Where the car was installed with the Mobileye system
- Photos of the CAN-bus cable connections



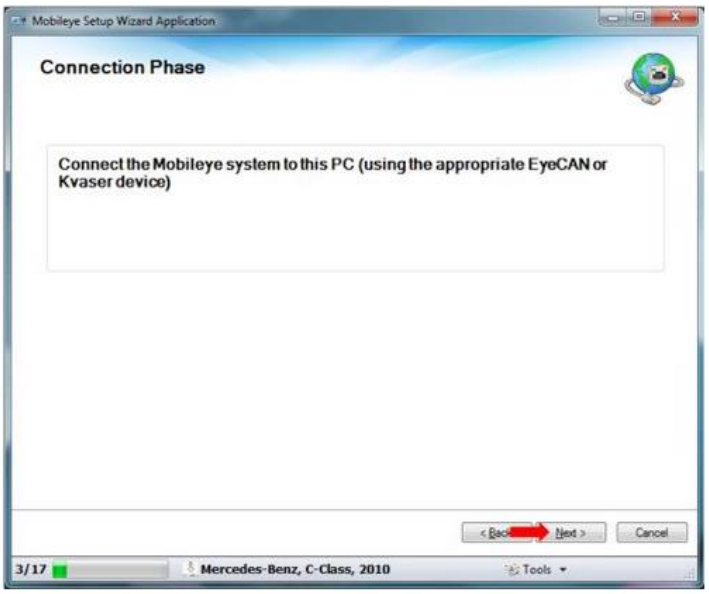
4. Click on "Accept selection" to choose the vehicle

5. After choosing the wanted vehicle from the Vehicle Database confirm it is show in the "User Identification and Accessories" slide (Screen 2/17)

- Click "Next >" to continue

6. (Screen 3/17 – Connection Phase) Make sure all the cables that connect the Mobileye 5 system to the laptop are connected securely before initiating connection between the Mobileye 5 system and the Mobileye Setup Wizard application.

- Click “Next >” to continue.

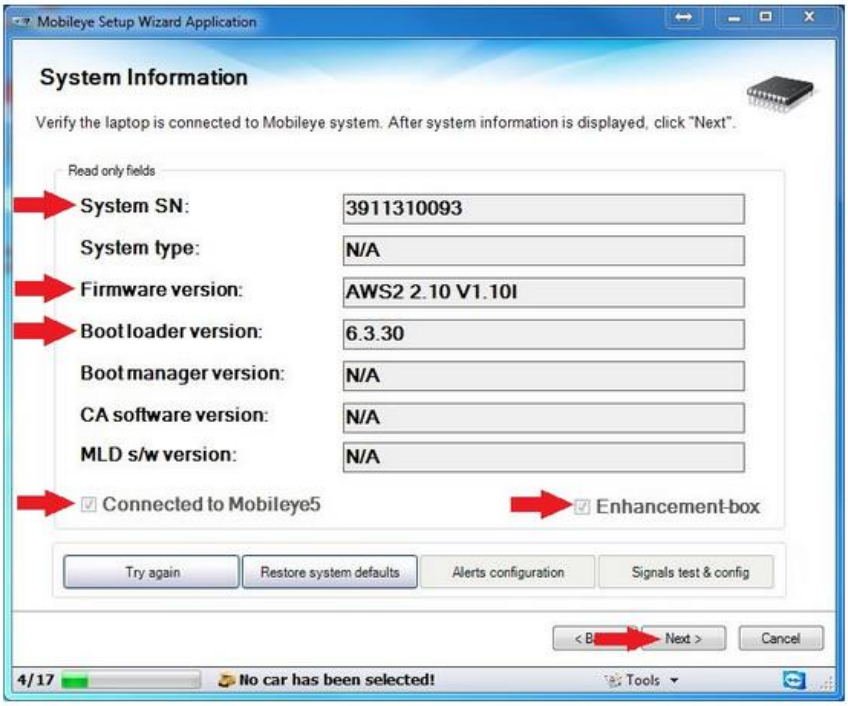


7. (Screen 4/17 – System Information) Verify that the system serial number (SN), the firmware version, and the boot
Loader versions are all identified by the Mobileye Setup Wizard application.

8. Verify that the message "Connected to Mobileye5" is checked with √. And also verify when using an Enhancement-box is checked with √.

- Click “Next >” to continue.

If the serial number, firmware version, or boot loader version are missing click “Try again” to retry to establish the connection or check your cables and power connections.

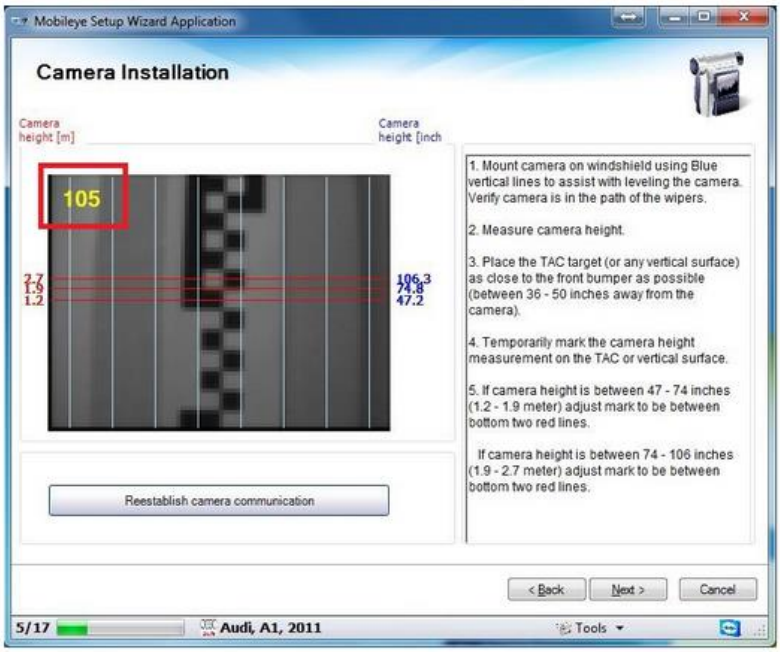


Lower pane additional buttons:

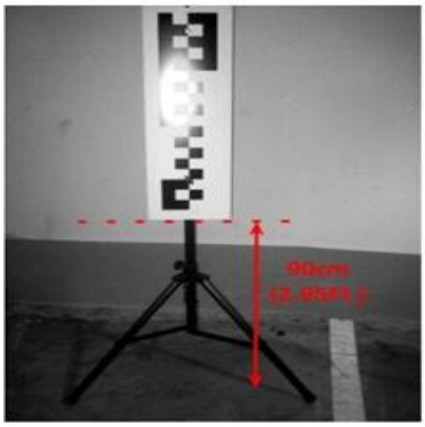
- Restore System Defaults – Resets the firmware to the analog default settings. Useful for resetting a system that was previously installed in another vehicle.
- Alerts configuration – Used to predefine system alert levels and sensitivities, volume levels, and button locking (enabled only for installers with special permissions granted by the local distributor).
- Signals Test & config – Used to test the system. Skips the calibration and links directly to the signals test & test drive slide.

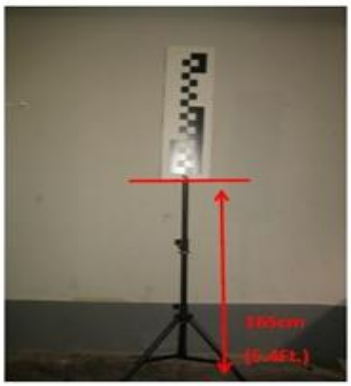
9. (Screen 5/17 – Camera Installation) After activating the Mobileye Setup Wizard, choosing the vehicle CAN profile from the Vehicle Database and connecting successfully to the Mobileye 5 unit, you should see the Camera image in the "Camera Installation" window of the Mobileye Setup Wizard:

- Make sure the yellow numbers on the upper left corner of the camera image window are running (meaning the Camera connection is working).
- If the number is steady click "Reestablish camera communication"



10. Locate the “TAC Target” exactly in the middle of the vehicle’s front bumper.
    - For cars – close as possible to the front bumper
    - For trucks – 1 meter (3.3ft.) away from front bumper
    - Make sure the TAC is open correctly (90cm/3ft. and 165cm/5.4ft.)



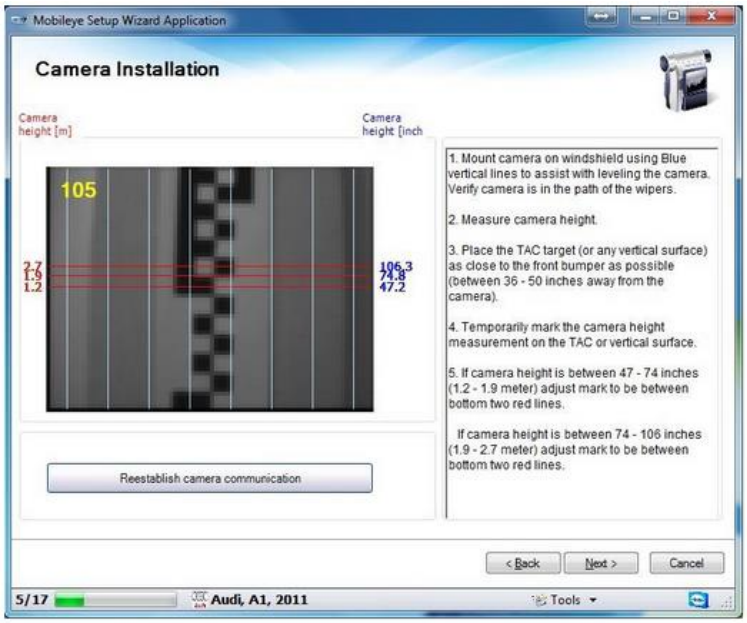


11. Attach the Camera to the Windshield

NOTE: Before attaching the Main Unit, verify there is enough place to take apart the Main Unit back covers using a small Philips screw driver.

NOTE: For Truck and Bus installations first remove the Main Unit back covers, Slide the Camera Down the railing to Level 6 and then follow steps.

12. Using the image feed (camera installation slide) start gluing the Camera from the top down, maintaining the horizontal lines in the scene ahead as the horizontal lines in the image window.



13. When completed, firmly attach the camera to the windshield in order to remove all air pockets between Camera Mount and Windshield.

5 System Calibration and Configuration

CAUTION: When Performing System Calibration DO NOT:

- Disconnect the EyeCAN cable connections
- Move the laptop carelessly
- Turn off the vehicle or in any other way turn off power to the Mobileye 5 system

5.1 Removing Mobileye 5 Back Cover

In order to calibrate the Mobileye 5, the Camera Angle must be set prior to the calibration process.

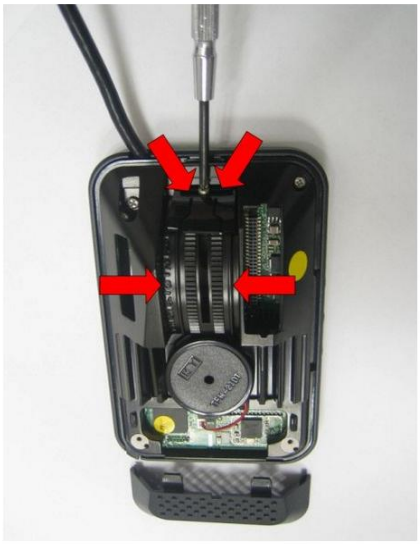
To access the Camera Adjustment Screw there is a need to remove the Mobileye 5 unit Back Covers. Table I: Supported CAN

1. Insert a small screw driver at the slightly larger circles at the right and Left ends of the lower part of the Main Unit Back Cover and press the bracket to release.

2. Once the 2 Brackets on the Left and Right side have been released pull the Lower small Back Cover downwards and remove completely.

3. Un-screw the 2 small screws on the Left and Right sides to remove the Upper Back Cover.

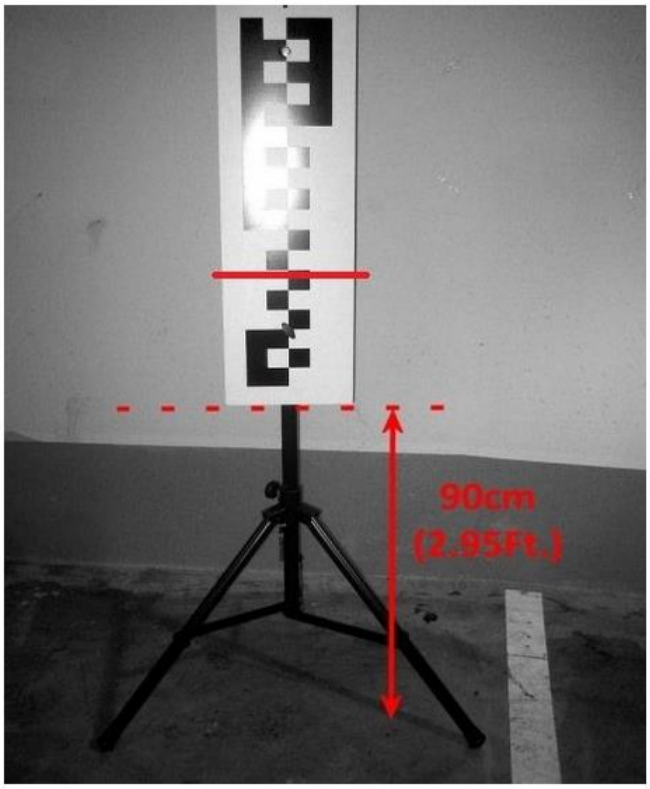
4. Once the 2 screws have been removed, remove the Upper cover completely.
5. Now use the Camera adjustment screw to set the correct camera angle by releasing the screw a little and moving the Camera along the Camera Railing.



5.2 Adjusting Camera Angle

1. Measure the Camera Height from the ground up using a measuring tape

2. Using a piece of isolation tape (See Red Line in below image); mark the Camera Height you measure on the TAC target.

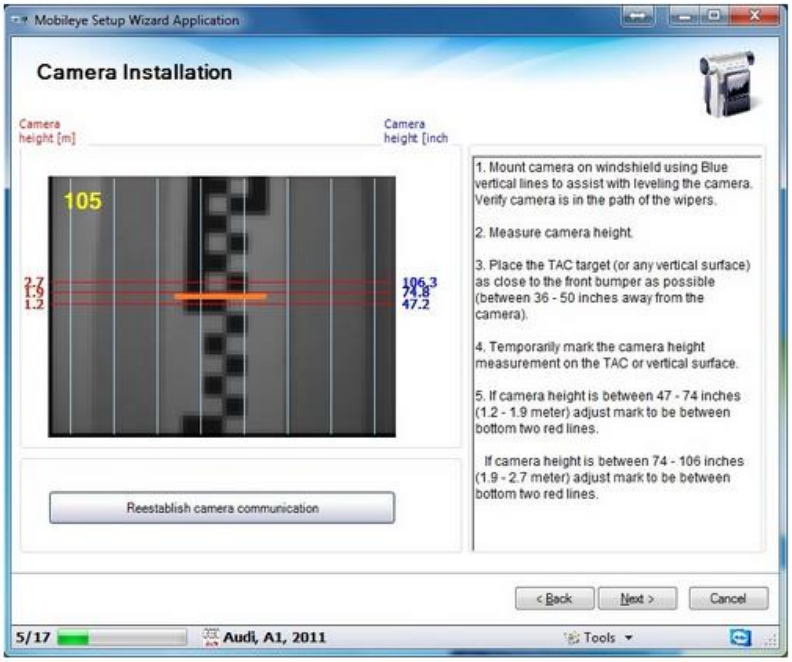


- When TAC target is assembled and open correctly the bottom part of the Checkered TAC board should be 90 cm (3ft.) from the ground.
- Each Checkered Box in the TAC board = 5 cm (1.96inch)
- Red Line represents Camera Height marked by Isolation tape at a Height of 1.24 cm
- If you do not have a TAC unit, you can mark the Camera Height you measured on any flat surface in front of the vehicle (ex. the garage wall

3. After marking the Camera Height on the TAC Target use the image feed (camera installation slide) to adjust the Camera Lens Angle by sliding it Up/Down the Camera Railing until the marked line is in the desired camera height range.

   a) If the Camera Height is between 1.2m (3.9ft) and 1.9m (6.2ft) place the Marked Line between the 2 bottom red lines (indicated by “1.2” and “1.9”) on the right hand of the
   Image feed = Range 1

   b) If the Camera Height is between 1.9m (6.2ft) and 2.7m (8.8ft) place the Marked Line between the 2 upper red lines (indicated by “1.9” and “2.7”) on the right hand of the image feed = Range 2



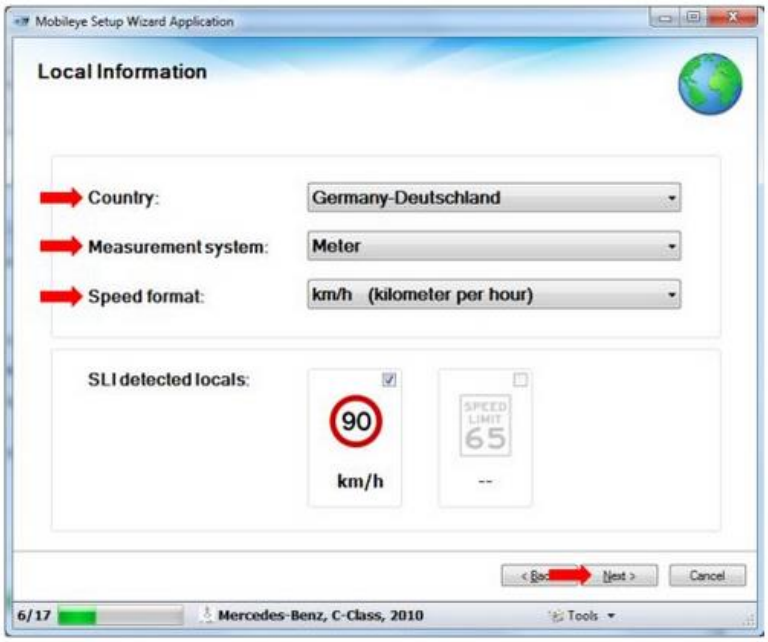
   In the example above, camera height is 1.4 meters so the Camera height marking is between the 2 bottom red lines (between 1.2 and 1.9)

4. Once the Camera Height is adjusted to the correct range, lock (tighten) the Camera Adjustment Screw and press "Next >" in the Mobileye Setup Wizard to continue.

   NOTE: Do not re-connect the Mobileye 5 unit Back Covers until the Calibration Process is completed.

5.3 System Calibration

1. Screen 6/17 – Local Information
   - Select your country.
   - Select the local measurement system.
   - Select the speed format.
   - The Speed Limit Information (SLI) will be automatically chosen to fit your Country" selection.
   - Click "Next >" to continue

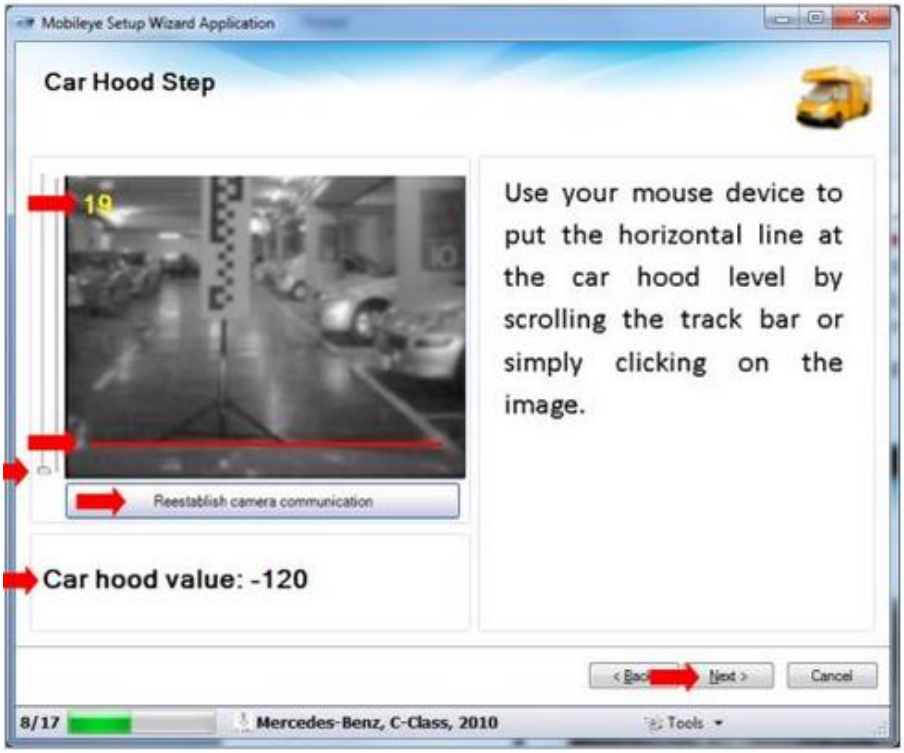


2. Screen 7/17 – Car Information
    - Enter the vehicle chassis number (at least 6 characters).
    - Measure and enter the front wheelbase (distance between the outer wheel sides).
        - Use a measuring tape, and place it on the floor while measuring.
        - When using the Metric system, enter the wheelbase in meters and not in centimeters (for example, 1.80 instead of 180).
        - When using imperial system do not forget to enter the value in inches.
        - Measuring tolerance = 2 cm (0.8 inch).

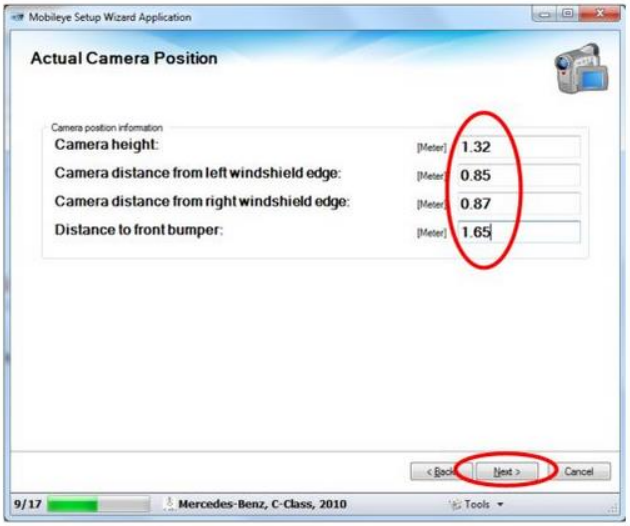
    - Select the road driving side
    - Click “Next >” to continue.

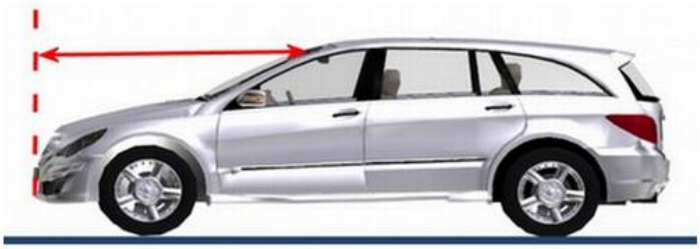
Note: The data of the vehicle you selected is shown automatically. To edit any details click on "Other..." and type in your comments.

3. Screen 8/17 – Car Hood
    - Make sure the yellow numbers on the upper left corner of the camera image window are running (meaning the Camera connection is working). If the number is steady click “Reestablish camera communication”.
    - Click the camera image (or move the side bar) to place a line on the car hood level.
    - If the car hood is not visible in the camera image leave the default car hood value at -120.
    - Click “Next >” to continue.

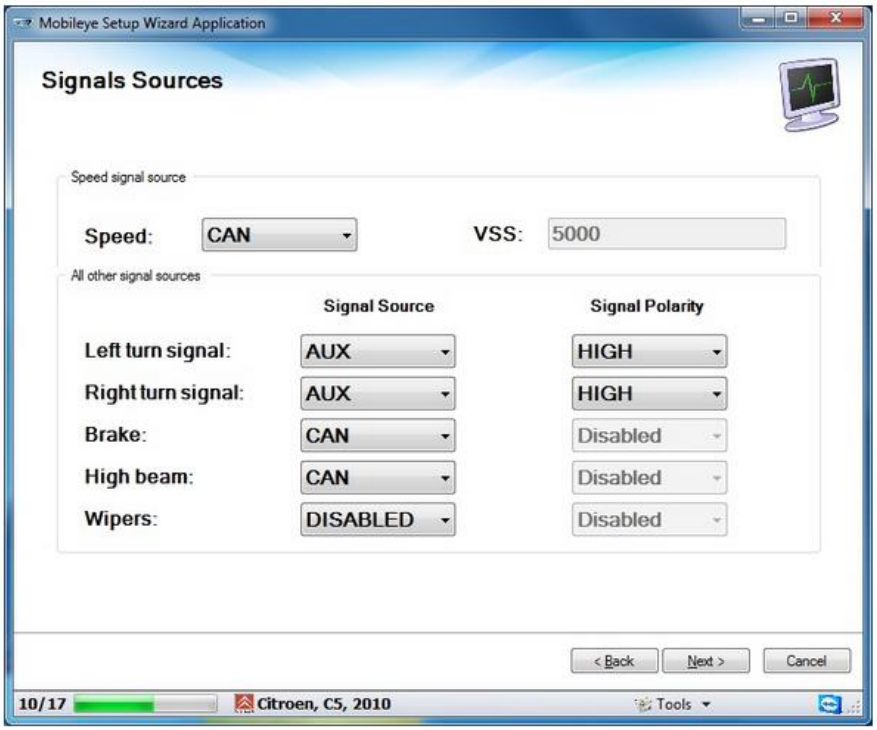


4. Screen 9/17 – Actual Camera Position
    - Measure and enter the height of the Camera unit accurately.
    - Measure and enter the distances on the outside of the vehicle between the Camera lens center and the left and right windshield outer edges.
    - Measure and enter the distance on the outside of the vehicle between the Camera lens center and the front bumper outer edge.
    - Enter Values
    - Click “Next >” to continue.





5. Screen 10/17 – Signal Sources
    - The Signal source slide informs you about the source of each signal.
    - In Mobileye 5 the Speed Signal Source will always be “CAN”
    - Mobileye 5 can be configured to work with 1 vehicle analog signal (or with both Left and Right Turn Indicators via Diode).
    - The 1 analog signal (or both Left and Right Turn Indicators) will be configured as AUX
    - CAN-Bus signals cannot be configured back to work with an Analog/AUX connection.
    - Signals not available by CAN/AUX will be disabled.
    - It is recommended not to make any changes if you followed the instructions in the Digital signals form” (CAN installation).
    - Signals which are available over CAN-bus do not have a Signal Polarity.
    - For every CAN-bus signal source the Signal Polarity setting will be automatically marked as - "Disabled"
    - Signals which are available over AUX have either a High or Low (Positive or Negative) signal polarity.
    - If both Right and Left Turn indicators are connected to the AUX wire via Diodes, the Signal polarity is automatically set to High (regardless of the real signal polarity).
    - Signals not available will be marked as "Disabled"
    - Click "Next >" to continue



5.4 Calibration Methods

Automatic Calibration

System will automatically calibrate during your first drive (between 5 to 10 minutes). If you choose Automatic Calibration you will be directed to the "Signal Test & Configuration" step or to the "Alerts configuration" step (if you have suitable user permissions)

Automatic Calibration

Automatic Calibration is a method of On-Road Calibration (without TAC target) for the Mobileye 5 system.

The Automatic Calibration was developed to offer quick system calibration for Service and Installation Points performing maintenance for Mobileye systems.

Automatic Calibration allows technicians to perform Calibration without TAC Target in cases it is not available (use of laptop is still required for first installation).

NOTE: Automatic Calibration is available only from Firmware version:

How does Automatic Calibration work?

- Automatic Calibration is a method of On-Road Calibration.
- The system calculates the correct calibration after a few minutes of driving.
- Road and Driving conditions affect the Automatic Calibration calculation.
- Automatic Calibration can work on any road although for best performance Mobileye recommends that Automatic Calibration is performed on straight stretches of road with 2 parallel lane markings. A steady and stable driving fashion also contributes to faster Automatic Calibration calculation.
- Automatic Calibration can be activated by the Mobileye Setup Wizard
- When Automatic Calibration is active no System Warnings are issued.
- Automatic Calibration duration is between 5 minutes to 15 minutes of driving depending on the road conditions.
- Automatic Calibration is available during the all-day hours.
- Automatic Calibration calculation is active only above 35km/h (22mph)
- During Automatic Calibration calculation, the system will emit a short beep every 5 seconds and the EyeWatch will display “CL” and a numerical counter (if EyeWatch display is connected to Mobileye 5). When reaching 99% calculation, the system will automatically restart and resume normal operation.

Activating the Automatic Calibration (via Mobileye Setup Wizard)

1- When reaching the “Camera Calibration” step (12/17), you will be asked to choose your preferred method of Camera Calibration: Automatic Calibration or Manual Calibration (TAC)

2- Press the button for the wanted calibration method (as shown in the previous page).

3- If you Press “Automatic Calibration” you will skip the Camera Calibration process and be directed automatically to the “Signals Test and configuration” Step (or to the Alerts configurations step if you have appropriate permissions).

4- During this time all the new system configurations you entered will be uploaded to the Mobileye System.

5- You will then conduct the Signals Test as usual and continue to the Test Drive.

6- Once you confirm all Signals are configured correctly, are active, and the Speed is correct, you should press next.

7- Before exiting the application you will be asked if you want to switch to Automatic Calibration mode and perform On-Road Calibration.

8- If you press yes the system will enter Automatic Calibration mode and will stay in this mode until it is successfully calibrated (even if vehicle Ignition is turned off and back on).

In Automatic Calibration mode, “CL” is visible on EyeWatch, and a percentage counter from 0% to 99% is also shown

A short beep emitted every 5 seconds from the system loud speaker will be evidence of Automatic Calibration mode activation.

Exiting Automatic Calibration mode (unlocking the camera)

Warning:

If Automatic Calibration mode was activated by mistake, the only way to cancel (Exit Automatic Calibration mode) is through the Mobileye Setup Wizard application (see below) or by successfully completing a Calibration Drive.

Switching the vehicle Ignition Off and back on in order to Cancel Automatic Calibration mode will not work.

After Automatic Calibration mode has been activated the system will boot in Automatic Calibration mode until it has been calibrated successfully.

If you wish to Exit Automatic Calibration mode (for any reason) follow the instructions below:

1- Connect the system to laptop computer and run the Mobileye Setup Wizard application

2- When the system is identified by the Mobileye Setup Wizard application in Step 4 (System Information) a Pop-Up window will show, asking you if you want to “Unlock the Camera” (from Automatic Calibration mode).

3- Press Yes to Unlock Camera (Exit Automatic Calibration mode)

4- After a few seconds a pop-up window will notify you that the “Camera was unlocked” (meaning you have Exited Automatic Calibration mode). Press “OK” to continue.

Error 13:

If Automatic Calibration is not successful after the first try, the Automatic Calibration process will automatically start Calibration again (the Automatic Calibration counter will start again from 0% to 99%).

If after the second try Automatic Calibration is still not successful Error 13 will appear.

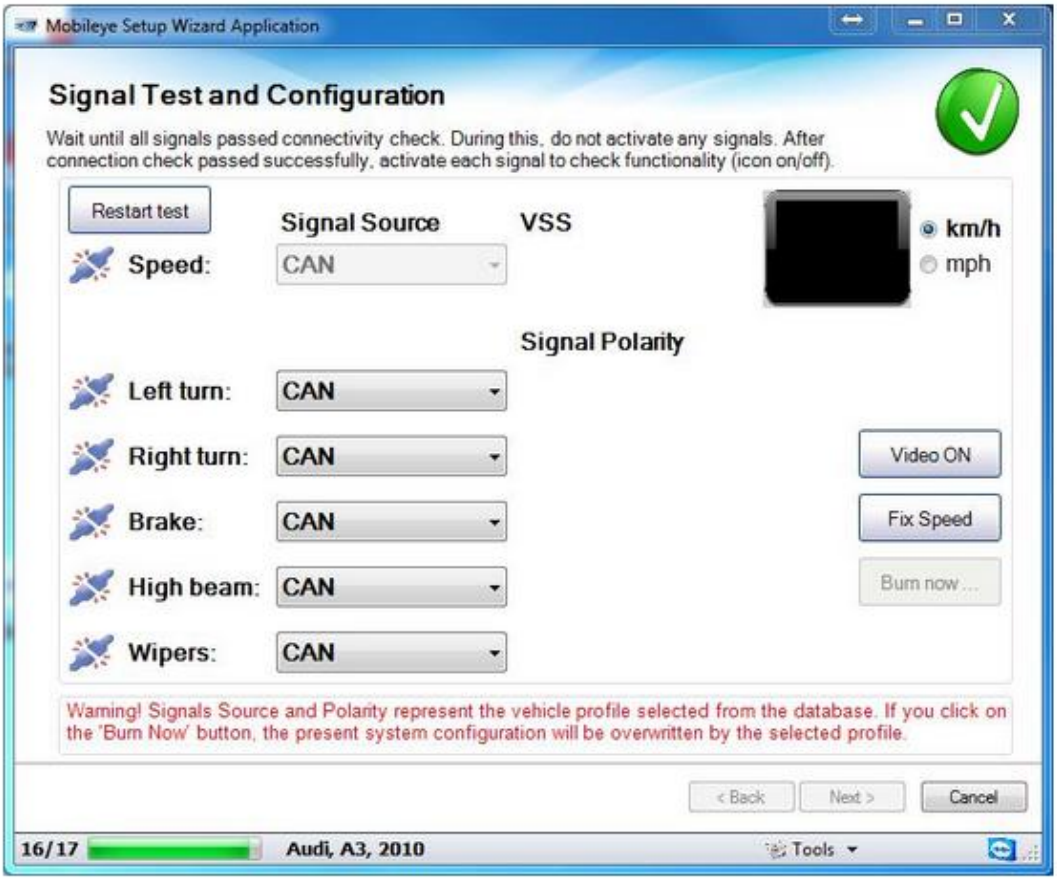
If Error 13 appears you need to Exit Automatic Calibration mode as described above.

If Automatic Calibration fails, it usually means that the Camera Angle is not adjusted correctly.

To adjust the camera angle you will need to Exit Automatic Calibration mode and adjust the camera angle.

5.5 Signal Test and Configuration

- Check physical connections of all signals to the Mobileye system - either by CAN or Analog).



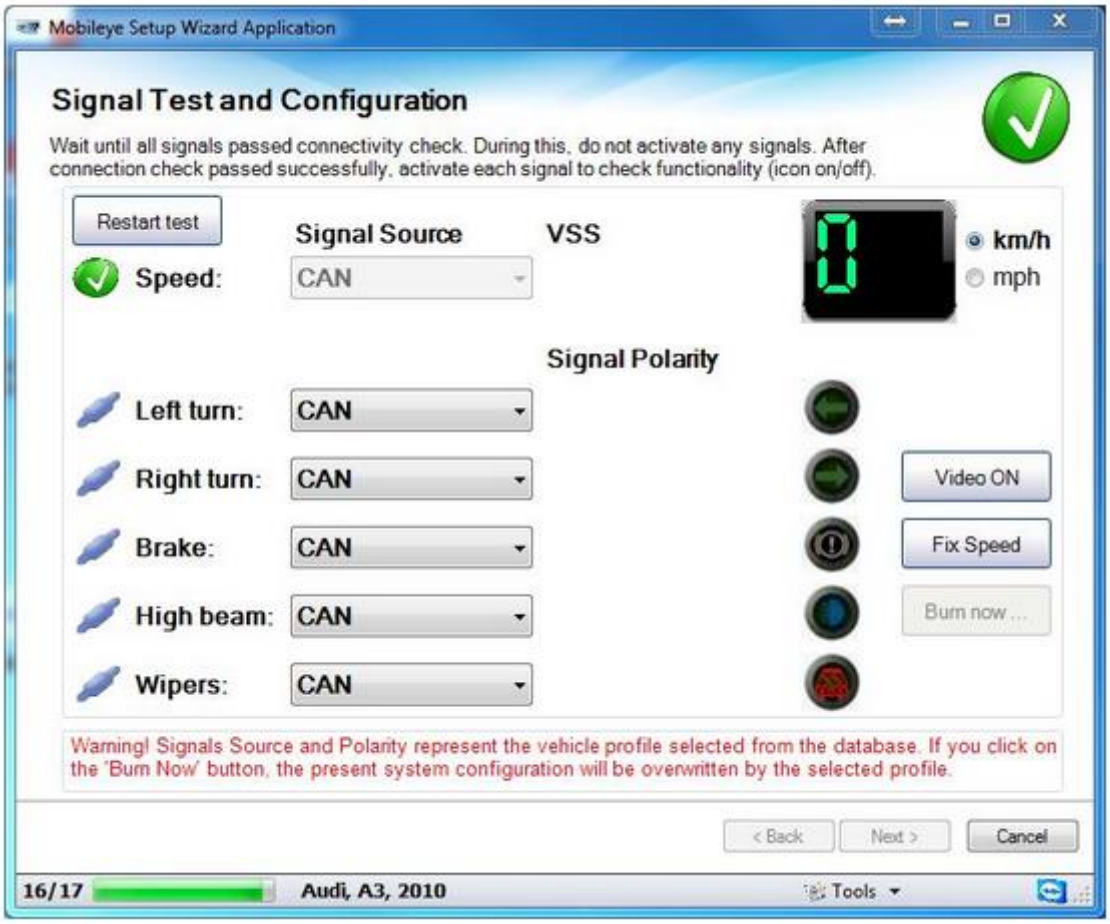
Signal is not detected by the Mobileye system

Signal is detected by the Mobileye system, but not activated

Signal is both detected and activated

Signal is disable

- Once all signals are identified by the ME5 system, the connection status will change.



- Activate each signal to pass the signal test step when activate any signal an activation icon will turn on as an indicator.
- Click "Restart test" button to retest if any of the signals did not pass the test.

5.6 Test Drive

Drive and confirm speed indication in the Mobileye setup wizard matches to the actual speed of the car.

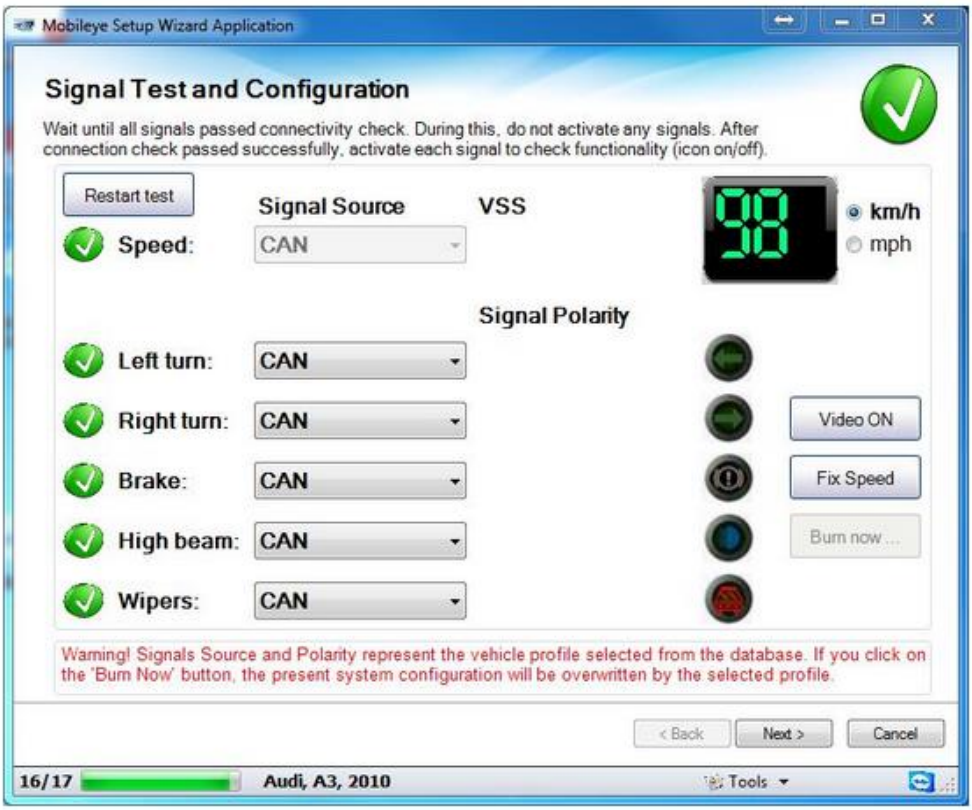
Note: Be aware that there is a 2 to 3 second delay between the vehicle speed to the speed indication in the Mobileye Setup Wizard application.

- Click **"Video ON"** if you want to see the camera image (low resolution) while performing the test drive.

- When using the analog speed signal and the real vehicle speed does not match the speed shown in the Mobileye setup wizard, you will need to change the VSS rate and click "Burn now" for the changes to take effect.
  (This option is available only when using the E-box).

- **Fix Speed** - OBDII universal speed signal acquisition (speed by request from OBD2) we will use this option if the speed signal is not accurate or not working.
  - Works only when connected to OBDII CAN-Bus on a bus speed of 250kbs or 500kbs (and only when connected to Pins 6 & 14 in OBDII)
  - Will not affect other signals received from the OBDII CAN-Bus.

SAFETY WARNING!
Drive carefully and according to the law during the test drive!



What you need to check while performing the test drive:

After the Speed indication has been verified and found to match the vehicle speed, disconnect the system from the laptop according to these instructions:

- Click “Next >”.
- Click “Finish” to close the Mobileye Setup Wizard application.
- Disconnect the EyeCAN cable from the laptop.
- Turn off the car and back on to reset the system.

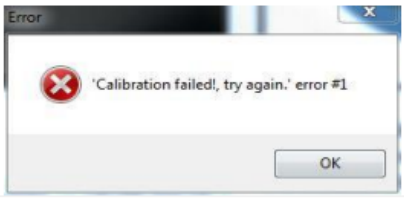
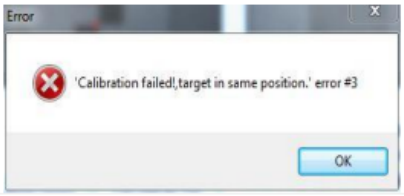
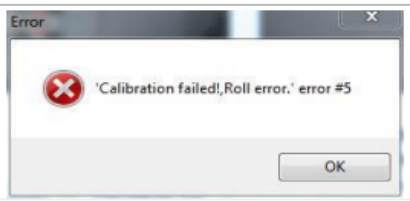
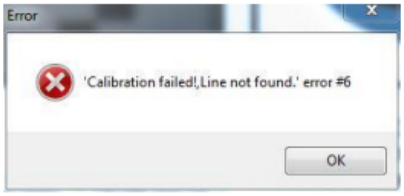
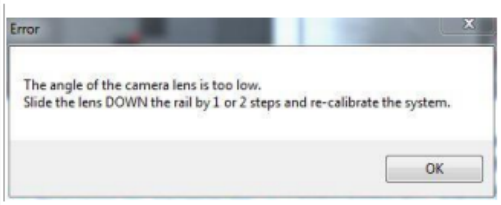
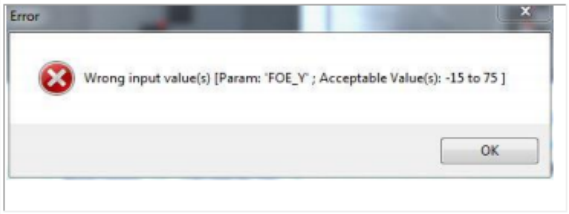
Verify features functionality:

- Drive behind a vehicle and verify vehicle detection (Green or red car icon on EyeWatch is available).
- While driving on a safe road test the LDW functionality.

Attention – So as not to endanger the installer, Mobileye does not recommend testing FCW and PCW!

6 Mobileye Error List

6.1 Mobileye Setup Wizard – Error List

Error code	Error description	Resolution
	Lighting issues. Target can't be found. (Same as Error #4)	Change the illumination level in the installation site (increase or decrease light)
	Target is in same position (for Close and Far TAC calculation) (Same as Error #2)	Move TAC target as instructed in the Camera Calibration TAC Close and Far position steps.
	Camera Image is not leveled Either TAC Target and/or Camera are crocked	Level your Camera or TAC Target and re-do calibration.
	Squares on target undetected May be a result of not enough TAC squares or unclear TAC squares. Min detected squares required-7	Make sure the TAC target is assembled, open and positioned correctly. Make sure the Camera angle is adjusted correctly.
	Re-adjust the camera angel and Re-calibrate the system	
	Re-adjust the camera angel and Re-calibrate the system	

6.2 Mobileye EyeWatch – Error List

Error code	Error details	Resolution	
Er - 10	Communication error with image sensor	*C2-270*	*M-5*
		Replace SeeQ	Check the flat cable of the camera
Er - 12	Camera initialization error	*C2-270*	*M-5*
		Replace SeeQ	Check the flat cable of the camera
Er - 13	Failure of Automatic Calibration	Exit Automatic Calibration mode, Re-adjust camera angel and run Automatic Calibration again	
Er - 20	Speed signal is configured by CAN-bus but the system is not detecting the vehicle CAN- bus	Verify CAN-bus connection, or check vehicle profile is correct	
Er - 39	Missing etc/EyeWatch.reg	Contact Mobileye support team	
Er – 55	Invalid horizon (FOE_Y) value, relative to the "Car Hood" level and Camera angel	Run Mobileye fix tool (using the Mobileye setup wizard > tools > Error Fix) and Adjust camera angel (As instructed in the "Camera installation" slide).	
Er - 57	The closest detected ground is more than 10m away. The camera is looking too high.	Run Mobileye fix tool (using the Mobileye setup wizard > tools > Error Fix) and Adjust camera angel (As instructed in the "Camera installation" slide).	
Er - AB	System is set to work with Enhancement-box but no E-Box is detected	Restore system to default	
Er - A0/A1	System is set to work with Enhancement-box but no E-Box is detected	Restore system to default	
Er - DA	The system is in Tamper Alert state	Check if the camera has a clear view	
–·– flashing rapidly	No communication between the camera and the EyeWatch	Check / replace EyeWatch & connections Check / replace PS3 connections Check / replace camera cable connector Check / replace camera	

7 How to Read CAN Messages (Kvaser LeafLight)

7.1 Setup Conditions

7.1.1 Kvaser Leaf Light v2

1. Install the driver before attaching your Kvaser hardware to the PC
2. Run the driver installation CD included with your Kvaser product and follow the on-screen instructions.
3. Plug in your Kvaser hardware. Part # (KVS-LL-V2-00685-0)
4. The Found New Hardware Wizard will detect and complete driver installation.
5. Confirm hardware installation by opening the Control Panel applet “Kvaser Hardware” and checking that your hardware is listed in the device tab. On the Device tab, select a channel of your device to check the hardware’s firmware version to determine if an update is available.

7.1.2 Kvaser CanKing

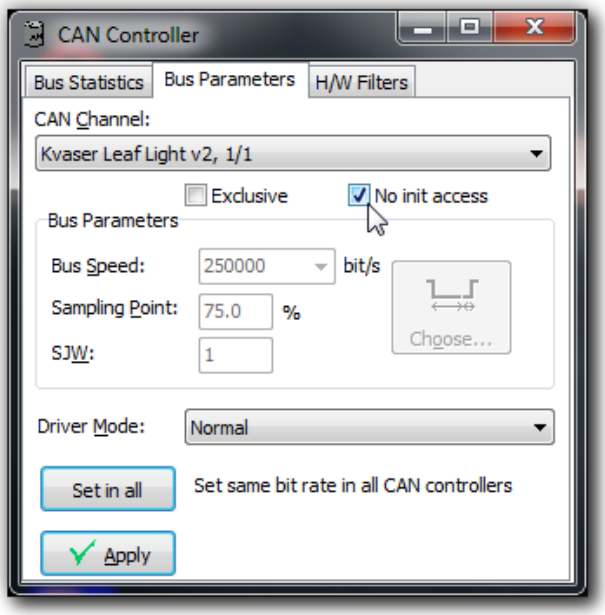
1. Run the CanKing installation CD included with your Kvaser product and follow the on-screen instructions.

7.1.3 Connecting Mobileye to Kvaser

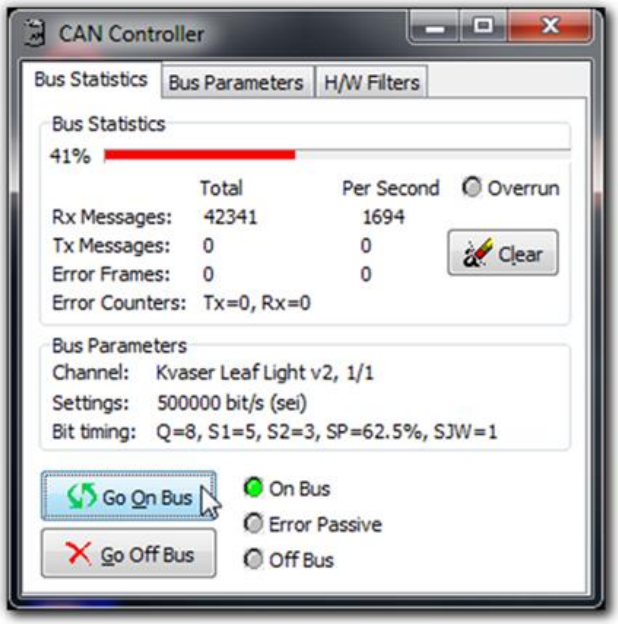
1. Locate the EyeCAN cable. This is the cable you plug into to configure the Mobileye.
2. Remove the plug from the end of the cable.
3. Connect the CAN High (Brown) to Pin 7 of a DB9 connector
4. Connect the CAN Low (Purple) to pin 7 of a DB9 connector.
5. Plug the DB9 connector into the Kvaser LeafLight v2.
6. Plug the Kvaser LeafLight v2 into the USB of Computer.

7.1.4 Establish Communications

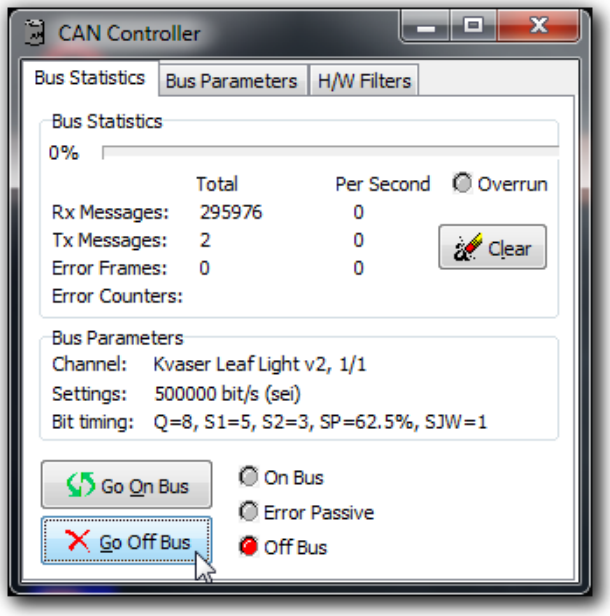
1. Start Kvaser CanKing.
2. Press Ok, I know what I'm doing
3. Create a new project using a template. Press OK
4. Select CAN Kingdom Basic template and press OK
5. OK the Tip of the Day.
6. In CAN Controller window under Bus Parameters check No init access



7. In CAN Controller Window under Bus Statistics press Go On Bus. You should begin receiving traffic.



8. You will begin to see traffic.
9. Press Go Off Buss.



8 AWS Extended Log Data Protocol 2

8.1 Introduction

This document describes the Extended Log Data Number 2 Protocol of the Mobileye AWS system. The ExtLogData2 Protocol is used to send out internal information and measurements from the AWS technologies – Vehicle Detection, Lane Departure Warning and Forward Collision Warning. The Protocol may be used by OEM's evaluating Mobileye's technologies, or by third party that wants to integrate Mobileye's system into their system (such as Fleet Management, fusion systems, Vision ACC systems, etc…).

In October 2009 the protocol was enhanced to include also reporting of traffic signs detection and Beam control.

In order to enable those, the configuration file needs to include not only "extLogData2" value but also:
- "meAWS" for message 0x700
- "meAHBC" for messages 0x728,0x729
- "meTSR" for messages 0x720-0x727

8.1.1 Purpose

The purpose of this document is to define the format of a CAN message that is used to send the results of the AWS calculations out.

8.1.2 Acronyms and Terminology

Term	Description
CAN	Controller Area Network
CIPV	Closest In Path Vehicle

8.2 CAN Messages

8.2.1 Can Parameters

- The message is transmitted in an 11bit CAN header format.
- The baud rates is configurable (250, 500 or 1000kbps). Default baud rate is 500Kbps
- The CAN message is transmitted approximately every 66-100 ms.
- ExtLogData2 Protocol activation value in calibration (meio.cfg): protocol: "extLogData2"
- TSR and AHBC messages are sent periodically, upon detection (not every frame)

8.2.2 ExtLogData2 Protocol

8.2.2.1 CAN Message 0x650 – Fixed FOE signals

This message contains the fixed FOE X & Y (mainly for visualization purposes)

Bit	7 (MSB)	6	5	4	3	2	1	0 (LSB)
Byte 0	Fixed Yaw							
Byte 1	Fixed Yaw							
Byte 2	Fixed Yaw							
Byte 3	Fixed Yaw							
Byte 4	Fixed Horizon							
Byte 5	Fixed Horizon							
Byte 6	Fixed Horizon							
Byte 7	Fixed Horizon							

8.2.2.1.1 Fixed Yaw

Type: Float
Meaning: The fixed FOE X in pixels

8.2.2.2 Fixed Horizon

Type: Float
Meaning: The fixed FOE Y in pixels

8.2.2.3 CAN Message 0x700 Details – AWS Display

This message contains the Display and Warnings signals.

Bit	*7 (MSB)*	*6*	*5*	*4*	*3*	*2*	*1*	*0 (LSB)*
Byte 0	Suppress	*Reserved*		Night Time	Dusk Time	Sound Type		

Bit	*7 (MSB)*	*6*	*5*	*4*	*3*	*2*	*1*	*0 (LSB)*
				Indicator	Indicator			
Byte 1	*Reserved*							
Byte 2	Headway Measurement							HW valid
Byte 3	*Reserved*							0x1
Byte 4	Failsafe	Maintenance	Right Crossing	Left Crossing	FCW on	Right LDW on	Left LDW on	Lanes On
Byte 5	*Reserved*					Ped in DZ	Ped FCW	*Reserved*
Byte 6	*Reserved*							
Byte 7	*Reserved*						Warning Level	

8.2.2.3.1 Suppress

Type: bool
Meaning: When new sound should be played and the old sound stopped, the suppress bit will turn on. Also when a sound should be suppressed, the suppress bit will turn on.

8.2.2.3.2 Night Time Indicator

Type: bool
Meaning: indicates if the system is in night mode (1) or not (0).

8.2.2.3.3 Dusk Time Indicator

Type: bool
Meaning: indicates if the system is in dusk mode (1) or not (0).

8.2.2.3.4 Sound Type

Type: unsigned char
Unit: Enum

0	silent
1	LDWL
2	LDWR
3	Far_HW (=HW1/HW2/HW3)
4	Near_HW
5	Soft FCW
6	Hard FCW + Peds FCW
7	Reserved

8.2.2.3.5 Headway Valid

Type: bool

Meaning: When Headway Valid bit is on, the HW measurement field will contain the Headway value.

8.2.2.3.6 Headway measurement

Type: unsigned char
Unit: 0.1 s
Range: 0 … 9.9

8.2.2.3.7 Lanes On

Type: bool
Meaning: When Lane Detection algorithms are functioning (speed condition), Lanes On bit is on.

8.2.2.3.8 Left/Right LDW On

Type: bool
Meaning: Indicator of Left/Right LDW event.
Note: The LDW will be ON for 5 consecutive frames, no matter how long the event really is

8.2.2.3.9 Left/Right Crossing

Type: bool
Meaning: Indicator of Left/Right Crossing event.
Note: The indicator will be given to ONE frame, when the internal Lanes Detection algorithm decides on lane switch

8.2.2.3.10

8.2.2.3.11 Maintenance

Type: bool
Meaning: Indicator of internal error. See User Manual.

8.2.2.3.12 FailSafe

Type: bool
Meaning: Indicator of one of the internal FailSafe modes (blur image, saturated image, low sun, partial blockage, partial transparent)

8.2.2.3.13 FCW on

Type: bool
Meaning: There is an FCW warning on a vehicle.

8.2.2.3.14 Ped FCW

Type: bool
Meaning: There is an FCW warning on a pedestrian.

8.2.2.3.15 Ped in DZ

Type: bool
Meaning: There is a DZ warning on a pedestrian (meaning, ped is in Danger zone).

8.2.2.3.16 Headway Warning Level

Type: unsigned char
Unit: HW Level (0-3 which is vehicle warning color).
Note: changes according to warning scheme setup. Default values:
When no CIPV is present, HW Level = 0 (Off)
When a CIPV is present with HW >1.0, HW Level = 1 (Green)
When a CIPV is present with 0.6 > HW >1.0, HW Level = 2 (Orange)
When a CIPV is present with HW < 0.6, HW Level = 3 (Red)

8.2.2.4 CAN Message 0x720,0x721,…,0x726 Details - TSR

CAN Messages 0x720…0x726 contain details about the TSR Type and Position.
7 messages are sent to support up to 7 signs in a specific frame.
Message 0x720…0x726 output is for each Traffic Sign recognized (1 frame per TS recognized)
Message output will occur only after a recognized Traffic Sign has exited the frame
The number of reported messages will be the number of detected signs in this frame + one additional message with "Vision only Sign Type" = "No sign detected" = message 0x727 (unless 7 signs were detected).

Bit	*7 (MSB)*	*6*	*5*	*4*	*3*	*2*	*1*	*0 (LSB)*
Byte 0	Vision only Sign Type							
Byte 1	Vision only Supplementary Sign Type							
Byte 2	Sign Position X							
Byte 3	Sign Position Y							
Byte 4	Sign Position Z							
Byte 5	Filter Type							
Byte 6	N/A							
Byte 7	N/A							

8.2.2.4.1 Vision only Sign Type

Type: Enum
Values:

Enum	Meaning
0	standard regular 10 kph
1	standard regular 20 kph
2	standard regular 30 kph
3	standard regular 40 kph
4	standard regular 50 kph
5	standard regular 60 kph
6	standard regular 70 kph
7	standard regular 80 kph
8	standard regular 90 kph
9	standard regular 100 kph
10	standard regular 110 kph
11	standard regular 120 kph
12	standard regular 130 kph
13	standard regular 140 kph
20	standard regular end restriction of number e.g 60 end of restriction.
28	standard electronic 10 kph
29	standard electronic 20 kph
30	standard electronic 30 kph
31	standard electronic 40 kph

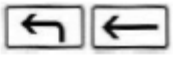
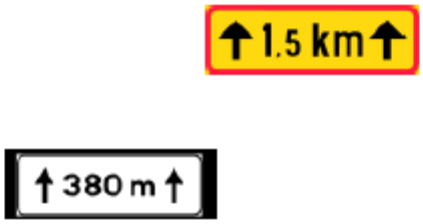
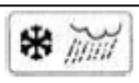
32 standard electronic 50 kph
33 standard electronic 60 kph
34 standard electronic 70 kph
35 standard electronic 80 kph
36 standard electronic 90 kph
37 standard electronic 100 kph
38 standard electronic 110 kph
39 standard electronic 120 kph
40 standard electronic 130 kph
41 standard electronic 140 kph
50 standard electronic end restriction of number e.g 60 end of restriction.
64 standard regular general end all restriction.
65 standard electronic general end all restriction.
100 standard regular 5 kph
101 standard regular 15 kph
102 standard regular 25 kph
103 standard regular 35 kph
104 standard regular 45 kph
105 standard regular 55 kph
106 standard regular 65 kph
107 standard regular 75 kph
108 standard regular 85 kph
109 standard regular 95 kph
110 standard regular 105 kph
111 standard regular 115 kph
112 standard regular 125 kph
113 standard regular 135 kph
114 standard regular 145 kph
115 standard electronic 5 kph
116 standard electronic 15 kph
117 standard electronic 25 kph
118 standard electronic 35 kph
119 standard electronic 45 kph
120 standard electronic 55 kph
121 standard electronic 65 kph
122 standard electronic 75 kph
123 standard electronic 85 kph
124 standard electronic 95 kph
125 standard electronic 105 kph
126 standard electronic 115 kph
127 standard electronic 125 kph
128 standard electronic 135 kph
129 standard electronic 145 kph
171 standard regular motorWay begin
172 standard regular end of fMotorWay
173 standard regular expressWay begin
174 standard regular end of ExpressWay
175 standard regular Playground area begin
176 standard regular End of playground area
200 standard regular no passing start
201 standard regular end of no passing

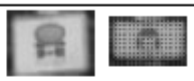
220 standard electronic no passing start
221 standard electronic end of no passing
254 No sign detected
255 e_invalid_sign

8.2.2.4.2 Supplementary Signs Types

Type: Enum
Values:

Name	Number	Examples	Comments
Rain	1		
Snow	2		
Trailer	3		
Time	4		

Arrow_left	5		Not yet supported. Not enough samples to train.
Arrow_right	6		
BendArrow_left	7		Not yet supported. Not enough samples to train.
BendArrow_right	8		In version 2.7 reported as arrow.
Truck	9		
Distance_arrow (distance for)	10		The restriction is for x KM. In version 2.7 reported as distance.
Weight	11		
Distance_in	12		Restriction in X meters from the sign. In version 2.7 reported as distance.
Tractor	13		New sign for 2.8. Not supported in 2.7. Overtake allow only for tractor.
Snow_rain	14		
School	15		Only for USA mode.

Rain_cloud	16		
Fog	17	Nebel	Not yet supported. Not enough samples to train.
Hazardous_materials	18		Reported as e_truck(9). No special class for this supplementary sign. We keep a place for future request.
Night	19		Not yet supported. Not enough samples to train. Only for USA mode.
Supp_sign_generic	20	A small rectangle below the circular sign. Good feature for fusion projects. We find a supplementary sign but we don't know the type of the supplementary sign.	Enable in version 2.8.
e_rappel	21		Support it for internal use. We do not want to declare it as generic supplementary sign since this is only a reminder. Enable in version 2.9.
e_zone	22		Detect the zone word below the sign. Enable in version 2.9.
Invalid_supp	255	Invalid value (should not occur).	
None	0	No supplementary sign was detected.	

8.2.2.4.3 Sign Position X

Type: unsigned Int
Range:0 122
Resolution: 0.5 meter
Meaning : The longitudinal position of the sign in the real world in meters.

8.2.2.4.4 Sign Position Y

Type: Signed Int
Range: -32… 31
Resolution: 0.5 meter
Meaning : The lateral position of the sign in the real world in meters. Negative refers to left and positive to right.

8.2.2.4.5 Sign Position Z

Type: signed Int
Range: -16… 16
Resolution: 0.5 meter
Meaning : The height of the sign in the real world in meters, relative to the camera location. Positive value refers to above the camera. Negative is below the camera.

8.2.2.4.6 Filter Type

Type: Enum
Meaning: The reason for filtering the sign. External filter, filtering visible signs to due irrelevance.
Values:

Value	Sign
0000	Not filtered
0001	Irrelevant to the host driver. I.e.: highway exits, 

	parallel roads, lane assignment sign,  etc.
0010	On vehicle/Truck 
0011	Embedded  

8.2.2.5 CAN Message 0x727 Vision only TSR – Continues

This message contains the TSR Vision only decision – continues value based on real decision.

This message will be reported as long as the sign is relevant.

Bit	7 (MSB)	6	5	4	3	2	1	0 (LSB)
Byte 0	Vision only Sign Type – Display 1							
Byte 1	Vision only Supplementary Sign Type – Display 1							
Byte 2	Vision only Sign Type – Display 2							
Byte 3	Vision only Supplementary Sign Type – Display 2							
Byte 4	Vision only Sign Type – Display 3							
Byte 5	Vision only Supplementary Sign Type – Display 3							
Byte 6	Vision only Sign Type – Display 4							
Byte 7	Vision only Supplementary Sign Type – Display 4							

8.2.2.5.1 Vision only Sign Type – Display 1 - 4

Type: Enum
Range: 0-255
Meaning: The speed vale is represented according to the speed sign, which is decoded according to the " Vision only Sign Type" table. Found in Section 8.2.2.3.1

8.2.2.5.2 Vision only Supplementary Sign Type – Display 1-4

Type: Enum
Range: 0-255
Meaning: The supplementary sign type is represented in "Supplementary Signs Types" Table. Found in section 8.2.2.3.2

8.2.2.6 CAN Message 0x728 Details – AHBC - high low beam

This message contains the control for high / low beam

	7 (MSB)	*6*	*5*	*4*	*3*	*2*	*1*	*0 (LSB)*
Byte 0	Reserved						Binary high/low beam decision	
Byte 1	Reasons for switch to low beam							
Byte2	Reserved							Reasons for switch to low beam

8.2.2.6.1 Binary high/low beam decision

Type: enum, 2 bits
Meaning :

00	0	No recomendation
01	1	Recommendation : high beam OFF
10	2	Recommendation : high beam ON
11	3	Signal invalid

8.2.2.6.2 Reasons for switch to low beam

Type: enum, 9 bits
Meaning : it could be few reason for switching low beam

0 0000 0000	No switch reason
bit 0	Oncoming vehicle
bit 1	Preceding vehicle
bit 2	Speed limit
bit 3	Ambient light
bit 4	Village detection
bit 5	Fog detection – Currently identified on High beam only

bit 6	Highway mode (note: no reason for low beam)
bit 7	Delay (hysteresis)
bit 8	Too many lights

8.2.2.7 CAN Message 0x729 Details – AHBC Gradual

The message contains information about lights locations and angles to them

	7 (MSB)	*6*	*5*	*4*	*3*	*2*	*1*	*0 (LSB)*
Byte 0	Boundary domain bottom non-glare HLB							
Byte 1	Boundary domain non-glare left hand HLB (LSB)							
Byte 2	Boundary domain non-glare right hand HLB (LSB)				Boundary domain non-glare left hand HLB (MSB)			
Byte 3	Boundary domain non-glare right hand HLB (MSB)							
Byte 4	Object Distance HLB							
Byte 5	Status Boundaries and Object Distance							
Byte 6				BusyScene	TooManyCars	RTargetChange	LTargetChange	
Byte 7								

8.2.2.7.1 Boundary_Domain_Bottom_Non-Glare_HLB

Lower boundary of the glare free area (GFA) in the image, given as angle with respect to the camera coordinate system. The point of horizon defines 0°; positive angles shall be counted upwards. If no object has been detected, BNDRY_DOM_BOT_NGL_HLB shall be set to 0 and ST_BNDRY_DOM_BOT_NGL_HLB shall be set to 'No object detected'.
Short name: BNDRY_DOM_BOT_NGL_HLB
Invalidity indicator: FFhex
Signal type: 8 Bit, unsigned Integer (Byte 0, Bit 0...Byte 0, Bit 7)
Range: -10 ... 10 deg
Conversion: (PH) = 0.1 * (HEX) - 10 [deg]

8.2.2.7.2 Boundary_Domain_Non-Glare_Left-Hand_HLB

Left boundary of the glare free area (GFA) in the image, given as angle with respect to the camera coordinate system. The point of horizon defines 0°; positive angles are counted counter clockwise. If no object has been detected,
BNDRY_DOM_BOT_NGL_HLB shall be set to 0 and
ST_BNDRY_DOM_BOT_NGL_HLB shall be set to 'No object detected'.
Short name: BNDRY_DOM_NGL_LH_HLB
Invalidity indicator: FFhex
Signal type: 12 Bit, unsigned Integer (Byte 1, Bit 0...Byte 2, Bit 3)
Range: -20.0 ... 20 deg
Conversion: (PH) = 0.1 * (HEX) - 20.0 [deg]

8.2.2.7.3 Boundary_Domain_Non-Glare_Right-Hand_HLB

Right boundary of the glare free area (GFA) in the image, given as angle with respect to the camera coordinate system. The point of horizon defines 0°; positive angles are counted counter clockwise. If no object has been detected,
BNDRY_DOM_BOT_DOM_NGL_HLB shall be set to 0 and
ST_BNDRY_DOM_BOT_NGL_HLB shall be set to 'No object detected'.
Short name: BNDRY_DOM_NGL_RH_HLB
Invalidity indicator: FFhex
Signal type: 12 Bit, unsigned Integer (Byte 2, Bit 4...Byte 3, Bit 7)
Range: -20 ... 20.0 deg
Conversion: (PH) = 0.1 * (HEX) - 20 [deg]

8.2.2.7.4 Object_Distance_HLB

Range of the closest object ahead of the vehicle defining the lower boundary of the glare free area (GFA). If no object has been detected, OBJ_DIST_HLB shall be set to 0 and ST_OBJ_DIST_HLB shall be set to 'No object detected'. If range measurement is not available or not implemented, ST_OBJ_DIST_HLB shall be set to 'signal invalid'.
Short name: OBJ_DIST_HLB
Invalidity indicator: FFhex
Signal type: 8 Bit, Unsigned Integer (Byte 4, Bit 0...Byte 4, Bit 7)
Range: 0 ... 400 m
Conversion: (PH) = (HEX)*2 [m]

8.2.2.7.5 Status_Boundary_Domain_Bottom_Non-Glare_HLB

State of the lower boundary of the glare free area.
Short name: ST_BNDRY_DOM_BOT_NGL_HLB
Invalidity indicator: 11b
Signal type: 2 Bit, Enum (Byte 5, Bit 0...Byte 5, Bit 1)

Code	Name/Description
00	No object detected (lower boundary not defined)
01	Lower boundary defined by preceding vehicle
10	Lower boundary defined by oncoming vehicle
11	Invalid signa

8.2.2.7.6 Status_Boundary_Domain_Non-Glare_Left-Hand_HLB

Short name: ST_BNDRY_DOM_NGL_LH_HLB
Invalidity indicator: 11b
Signal type: 2 Bit, Enum (Byte 5, Bit 2...Byte 5, Bit 3)

Code	Name/Description
00	No object detected (left boundary not defined)
01	Left boundary defined by preceding vehicle
10	Left boundary defined by oncoming vehicle
11	Invalid signal

8.2.2.7.7 Status_Boundary_Domain_Non-Glare_Right-Hand_HLB

Short name: ST_BNDRY_DOM_NGL_RH_HLB
Invalidity indicator: 11b
Signal type: 2 Bit, Enum (Byte 5, Bit 4...Byte 5, Bit 5)

Code	Name/Description
00	No object detected (right boundary not defined)
01	Right boundary defined by preceding vehicle
10	Right boundary defined by oncoming vehicle
11	Invalid signal

8.2.2.7.8 Status_Object_Distance_HLB

Short name: ST_OBJ_DIST_HLB
Invalidity indicator: 11b
Signal type: 2 Bit, Enum (Byte 5, Bit 6...Byte 5, Bit 7)

Code	Name/Description
00	No object detected (object range not defined)
01	Preceding vehicle detected
10	Oncoming vehicle detected
11	Invalid signal

8.2.2.7.9 Left Target Change

Type: 1 bit, boolean
Range 0:1
Default value: 0
Indicates when the extreme left target has changed.

0	the extreme left target is the same as before
1	the extreme left target has changed since last frame.

8.2.2.7.10 Right Target Change

Type: 1 bit, Boolean
Range 0:1
Default value: 0
Indicates when the extreme right target has changed.

0	The extreme right target is the same as before
1	The extreme right target has changed since last frame.

8.2.2.7.11 Too Many Cars

Type: 1 bit, boolean
Range 0:1
Default value: 0
When the number or relevant light sources or vehicles detected by the camera is higher than 12 – this flag is turned on. The flag will be turned off only once then number is 6 or below (these numbers are configurable)

0	The number of relevant light sources and the number of vehicles detected by the camera don't exceed the specified thresholds
1	Too many light sources or vehicles are detected by the camera

8.2.2.7.12 Busy Scene

Type: 1 bit, boolean
Range 0:1
Default value: 0
The following conditions need to be met for a Busy scene:
The non-dazzling-area (The U-shape bounding all the approved oncoming and preceding objects in the image) covers at least ~4 degrees, both left and right of the image.
There are a few vehicles (at least 3) approved by Vehicles Detection technology
At least one of them is closer than 60m. (If there are more than 5 vehicles detected this condition doesn't have to be met)

8.2.2.8 CAN Message 0x737 Details – Lane

The message contains the Lane information and measurements.

	7 (MSB)	6	5	4	3	2	1	0 (LSB)
Byte 0	Lane Curvature (LSB)							
Byte 1	Lane Curvature (MSB)							
Byte 2	Lane Heading (LSB)							
Byte 3	NA	Left LDW Availability	Right LDW Availability	CA	Lane Heading (MSB)			
Byte 4	Yaw Angle (LSB)							
Byte 5	Yaw Angle (MSB)							
Byte 6	Pitch Angle (LSB)							
Byte 7	Pitch Angle (MSB)							

8.2.2.8.1 Lane Curvature

Type: signed integer
Units: 1/m
Range -0.12 : 0.12 [1/m]
Conversion: (HEX)*3.81*10-6
Invalid value: 8000h
Note: The Curvature (a) parameter in the equation: y= ax^2 + bx+ c
To extract the road radius (r) from curvature (a): r = 1/(2*a).

8.2.2.8.2 Lane Heading

Type: signed integer
Range: -1.0 : 1.0
Conversion: (HEX)*0.0005
Invalid value: 800h
Note: The Heading (b) parameter in the equation: y= ax^2 + bx+ c

8.2.2.8.3 CA – construction area

Type Boolean .

8.2.2.8.4 Pitch Angle

The pitch angle information of the host vehicle (derived from lanes analysis).
Type: unsigned 16 bits
Unit: radians
Range: -0.05 : 0.05
Conversion: (HEX-0x7FFF)/1024/512

8.2.2.8.5 Yaw Angle

The yaw angle information of the host vehicle (derived from lanes analysis).
Type: unsigned 16 bits
Unit: radians
Conversion: (HEX-0x7FFF)/1024

8.2.2.8.6 Right LDW Availability

Availability of LDW for the Right lane mark.
Type: 1 bit, unsigned integer
Range 0 ,1
Invalid value: none
0 stands for unavailable, 1 for available.

8.2.2.8.7 Left LDW Availability

Availability of LDW for the Left lane mark.
Type: 1 bit, unsigned integer
Range 0 ,1
Invalid value: none
0 stands for unavailable, 1 for available.

8.2.2.9 CAN Message 0x738 Details – Obstacle Status

This message contains the number of obstacles, the timestamp and the application version. Obstacles can be vehicles, Motorcycles or pedestrians.

	7 (MSB)	6	5	4	3	2	1	0 (LSB)
Byte 0	Num_Obstacles							
Byte 1	Timestamp							
Byte 2	Application_Version							
Byte 3	Go!				Right close rang cut in	Left close rang cut in	Active Version Number Section	
Byte 4	Protocol Version							
Byte 5	Reserved				Failsafe			Close Car

8.2.2.9.1 Num_Obstacles

Type: unsigned integer
Range: 0 : 255

8.2.2.9.2 Timestamp

Type: unsigned integer
Unit: milliseconds
Range: 0 : 255 [ms]
Note: Only the lowest 8 bits of the timestamp is given. The timestamp source is from the EyeQ image grabbing.

8.2.2.9.3 Application_Version

ME software Version number – the available section for this frame. The version number is reported during 4 frames long, according to the active version number section (see 3.1.8.3). It should consists of X.Y.Z.W, where X is the major version (index 0), Y is the minor (index 1), Z is the customer (index 2), and W is pre/post version (index 3). For example: 2.2.1.15
Type: 8 bit, unsigned integer
Range 0 : 255
Conversion: (Hex)*1
Invalid value: none

8.2.2.9.4 Active Version Number Section

The index of the active section of Application_Version signal, which is available for this frame.
Type: 2 bit, unsigned integer
Conversion: (Hex)*1
Range 0 : 3
Invalid value: none

8.2.2.9.5 Left close rang cut in

Type: Boolean
0 false, 1 true

8.2.2.9.6 right close rang cut in

Type: Boolean
0 false, 1 true

8.2.2.9.7 Go!

Type: Enum
Values:
0 – Stop
1 – Go!
2 – Undecided
3 - Driver decision is required
…. [4-14 - currently unused]
15 – Not Calculated

8.2.2.9.8 Current status of this signal:

o Reports only values of 0 or 1 or 15
o Reports Stop or Go decisions only when the own vehicle is standing (having ego speed of less than 0.1 meters per second). Otherwise, the value 15 is reported.

8.2.2.9.9 Protocol Version

The index of current protocol version.
Type: unsigned char, 8 bit length
Range: 0x00 .. 0xff

8.2.2.9.10 Close car

Indication whether we detect a close car in front of the host vehicle or not.
Type: Boolean
0 No close car 1 Close car exists

8.2.2.9.11 Failsafe

Type: 4 bits, unsigned integer
Range 0 : 7
Invalid value: 0
Bitwise signal, which indicates failsafe situation in this scene.
Values:
0000 – No Failsafe
0001 – Low Sun
0010 – Blur Image
0100 – unused
1000 – unused

*8.2.2.10 CAN Message 0x739 + i*3 Details – Obstacle Data A*

Where i = 0 : num_obstacles - 1
This message contains obstacle detection information and measurements.

Bit	7 (MSB)	6	5	4	3	2	1	0 (LSB)
Byte 0	Obstacle_ID							
Byte 1	Obstacle_Pos_X (LSB)							
Byte 2					Obstacle_Pos_X (MSB)			
Byte 3	Obstacle_Pos_Y (LSB)							
Byte 4	Cut in and out			Blinker Info			Obstacle_Pos_Y (MSB)	
Byte 5	Obstacle_Rel_Vel_X (LSB)							
Byte 6	Reserved	Obstacle_Type			Obstacle_Rel_Vel_X (MSB)			
Byte 7	Obstacle_Valid		Reserved		Obstacle_Brake_Lights	Obstacle_Status		

8.2.2.10.1 Obstacle_ID

Type: unsigned integer
Range: 0 : 63
Note: New obstacles are given the last used free ID.

8.2.2.10.2 Obstacle_Pos_X

Type: unsigned integer
Unit: meter
Range: 0 : 250 [m]
Conversion: (HEX)*0.0625
Invalid value: FFFh
Meaning: The longitude position of the obstacle relative to the reference point. This field is computed from the image position of the obstacle and from the detected width of the obstacle. The value is filtered to provide smooth measurements, and in order to avoid measurements outliers. In General, the value error is below 10% or 2 meters (the larger of the two) in ~85% of the cases.

8.2.2.10.3 Obstacle_Pos_Y

Type: signed integer
Unit: meter
Range: -31.93 : 31.93 [m]
Conversion: (HEX)*0.0625
Invalid value: 200h
Meaning: The lateral position of the obstacle. This field is computed from the image position of the obstacle and from the Position X value, so that we can report real world coordinates and not just angle from the camera. The value is filtered to provide smooth measurements, and in order to avoid measurements outliers. The typical error is correlated to Pos_X measurement's error.

8.2.2.10.4 Obstacle_Rel_Vel_X

Type: signed integer
Unit: meter/sec
Range: -127.93 : 127.93 [m/s]
Conversion: (HEX)*0.0625
Invalid value: 800h
Meaning: The relative longitude velocity of the obstacle. This field is computed from the obstacle scale change in the image. The value is a single frame value.

8.2.2.10.5 Obstacle_Type

Type: 3 bits, unsigned integer
Range 0 : 7
Invalid value: none
Enumerator signal, which indicates the object's classification
Enumerator values:
000 – Vehicle
001 – Truck
010 – Bike
011 – Ped
100 – Bicycle
101 – unused
110 – unused
111 – unused

8.2.2.10.6 Obstacle_Status

Type: unsigned integer
Unit: Enum

0	Undefined
1	Standing (never moved, back lights are on)
2	Stopped (movable)
3	Moving
4	Oncoming
5	Parked (never moved, back lights are off)
6	Unused

8.2.2.10.7 Obstacle_Brake_Lights

Type: 1 bit, boolean
Range 0:1
Invalid value: 0
Conversion: (HEX)*1
A flag indicating that the object's brake lights are on.

0	object's brake lights are off, or not identified
1	object's brake lights are on

8.2.2.10.8 Cut in and out

Type: unsigned integer
Enum : undefined = 0, in_host_lane = 1, out_host_lane = 2, cut_in = 3, cut_out = 4
The signal is based on our estimation of where the target is now relatively to the lanes, its rate of change, and our estimation of where it is going to be within one second.
The states are self explanatory. For instance, cut_in means target is now entering host lane, cut_out means it is now exiting host lane, etc.
The cut in and out signal does not distinguish between sides, i.e. left and right.

8.2.2.10.9 Blinker Info

Type: unsigned integer
Unit: Enum : unavailable=0, off=1, left=2, right=3, both=4.
Indicated Blinkers status

8.2.2.10.10 Obstacle_Valid

Type: unsigned integer
Unit: Enum

1	New valid (detected this frame)
2	Older valid

*8.2.2.11 CAN Message 0x73A + i*3 Details - Obstacle Data B*

Where i = 0 : num_obstacles - 1
This message contains obstacle detection information and measurements.

	7 (MSB)	6	5	4	3	2	1	0 (LSB)
Byte 0	Obstacle_Legnth							
Byte 1	Obstacle_Width							
Byte 2	Obstacle_Age							
Byte 3	Radar_Pos_X (LSB)				reserved	CIPV_Flag	Obstacle_Lane	
Byte 4	Radar_Pos_X (MSB)							
Byte 5	Radar_Vel_X (LSB)							
Byte 6	reserved	Radar_Match_Confidence			Radar_Vel_X (MSB)			
Byte 7	reserved	Matched_Radar_ID						

8.2.2.11.1 Obstacle_ Length

Type: unsigned integer
Units: meter
Range: 0 : 31 [m]
Conversion: (HEX)*0.5
Invalid value: 3Fh
Meaning: The length of the obstacle (longitude axis). Updated only for next lane vehicles that are fully seen, and only if the system has found the front edge of the vehicle. We don't have recent information regarding the signal's accuracy.

8.2.2.11.2 Obstacle_ Width

Type: unsigned integer
Unit: meter
Range: 0 : 12.5 [m]
Conversion: (HEX)*0.05
Invalid value: FFh
Meaning: The width of the obstacle (lateral axis). This value is calculated from the width in the image and the obstacle distance. The value is filtered to avoid outliers. The expected performance is to have error < 10% of the width in 90% of the cases. At night, the width measured is between the obstacle's taillights.

8.2.2.11.3 Obstacle_ Age

Type: unsigned integer
Range: 0 : 255
Meaning: The age of the obstacle (in frames). This value starts at 1 when the obstacle is first detected, and increments in 1 each frame. The value reported is min(realAge, 254), which means that it remains 254 if the age is larger than that number.

8.2.2.11.4 Obstacle_ Lane

Type: unsigned integer
Unit: Enum

0	Not assigned
1	Ego lane
2	Next lane (left or right), or next next lane
3	Invalid signal

Note: This value is calculated form the obstacle position and the lane detection or the headway model (yaw rate based or vision based) of the vehicle. The lane assignment decision usually takes up to 5 frames from the first detection of the obstacle.

8.2.2.11.5 CIPV_Flag

Type: unsigned integer
Unit: Enum

0	Not CIPV
1	CIPV

Note: This value is calculated from the obstacle position and the lane detection or the headway model (yaw rate based or vision based) of the vehicle. The lane assignment decision usually takes up to 5 frames from the first detection of the obstacle.

8.2.2.11.6 Radar_Pos_X

Type: unsigned integer
Unit: meter
Range: 0 : 250 [m]
Conversion: (HEX)*0.0625
Invalid value: FFFh (also in case on no radar target matched)
Meaning: The longitude position of the primary radar target matched to the vision target (if applicable), distance is given in relative to the reference point and not the camera. If no radar target is matched, the value will be 0xFFFh.

8.2.2.11.7 Radar_Vel_X

Type: signed integer
Unit: meter/sec
Range: -127.93 : 127.93 [m/s]
Conversion: (HEX)*0.0625
Invalid value: 800h (also in case on no radar target matched)
Meaning: The longitude velocity of the radar target matched to the vision targets (if applicable) . If no radar target is matched, the value will be 0xFFF.

8.2.2.11.8 Radar_Match_Confidence

Type: unsigned integer
Range 0:5 over 3 bits
Invalid value: 0h
Meaning: confidence of the radar match:
0: No match
1: Multi match, radar does not describe well the vision obstacle.
2-4: vision - radar match, with bounded error between vision and radar measurements, higher match confidence yield smaller error
5: high confidence match, with small error between Radar and vision measurement

8.2.2.11.9 Matched_Radar_ID

Type: unsigned integer
Range 0:127
Invalid value: 7fh
Meaning: ID of Primary radar target matched to the vision target if applicable.

*8.2.2.12 CAN Message 0x73B + i*3 Details - Obstacle Data C*

Where i = 0 : num_obstacles - 1
This message contains obstacle detection information and measurements.

Bit	7 (MSB)	6	5	4	3	2	1	0 (LSB)
Byte 0	Obstacle_Angle_Rate (LSB)							
Byte 1	Obstacle_Angle_Rate (MSB)							
Byte 2	Obstacle_Scale_Change (LSB)							
Byte 3	Obstacle_Scale_Change (MSB)							
Byte 4	Object_Accel_X							
Byte 5	Reserved			Obstacle Replaced			Object_Accel_X	
Byte 6	Obstacle_Angle (LSB)							
Byte 7	Obstacle_Angle (MSB)							

8.2.2.12.1 Obstacle_Angle_Rate

Type: signed integer
Unit: degree
Range: -327.68 : 327.68 [degree/sec]
Conversion: (HEX)*0.01
Meaning: Angle rate of Center of Obstacle in degrees/sec. A negative angle rate indicates that the obstacle has moved to the left (clockwise axis system). This value is calculated based on delta angles reported from the reference point in two consecutive frames.

8.2.2.12.2 Obstacle_Scale_Change

Type: signed integer
Unit: pix/sec
Range: -6.5532 : 6.5332 [pix/sec]
Conversion: (HEX)*0.0002
Invalid value: 7FFh

8.2.2.12.3 Object_Accel_X

The longitude acceleration of the object.
Type: 10 bit, signed integer
Range: -14.97 : 14.97 [m/s2]
Conversion: (HEX)* 0.03
Invalid value: 200h

8.2.2.12.4 Obstacle_Replaced

Type: Boolean

0	Not replaced in this frame
1	Replace in this frame

8.2.2.12.5 Obstacle_Angle

Type: signed integer
Unit: degree
Range: -327.68 : 327.68
Conversion: (HEX)*0.01
Meaning: Angle to Center of Obstacle in degrees. 0 indicates that the obstacle is in exactly in front of us (along the longitudinal axis); a positive angle indicates that the obstacle is to the right (clockwise axis system). This value is calculated from the reference point, and is based on the obstacle's location in the image and the distance estimation in order to provide measurements in the real world. The angle error can have errors with correlation to the distance measurements error.

8.2.3 AfterMarket_Ext

8.2.3.1 RQEXT2_2

The protocol broadcast via CAN1 in baud rate 500 Kbytes
The CAN message is transmitted every 100 ms.

8.2.3.2 CAN Message 0x669 Details - Lane

The message contains the Lane information and measurements.

	7 (MSB)	6	5	4	3	2	1	0 (LSB)
Byte 0	Lane type left				Undocumented	LDW available left	Lane confidence left	
Byte 1	Distance to left lane (LSB)				Reserved			
Byte 2	Distance to left lane (MSB)							
Byte 3	Reserved							
Byte 4								
Byte 5	Lane type right				Undocumented	LDW available right	Lane confidence right	
Byte 6	Distance to right lane (LSB)				Reserved			
Byte 7	Distance to right lane (MSB)							

8.2.3.2.1 Distance to lane (left and right)

Type: signed integer
Unit: meter
Range: -40 : 40 [m]
Conversion: (HEX)*0.02
Invalid value: 800h
Note: The Offset (c) parameter in the equation: y= ax^2 + bx+ c

8.2.3.2.2 Lane Confidence (left right)

Confidence grade about the right lane information
Type: 2 bits, unsigned integer
Range 0 : 3
Invalid value: none
0 is the lowest confidence and 3 is the highest.

8.2.3.2.3 LDW Availability

Should be on whenever the system detects lanes.at confidence >=2
And speed is>55km/h +hysteresis, and configuration of the LDW is >=1

8.2.3.2.4 Lane Type

Type: int
Unit: Enum

0	Dashed
1	Solid
2	None
3	Road Edge
4	Double Lane Mark
5	Bott's Dots
6	Invalid

8.2.4 LKA common CAN protocol

This document describes the LKA common CAN protocol. The protocol outputs LKA required signal including for each lane: lane type and position, lane mark curvature and curvature derivative (if relevant), host heading relating lane mark. It also reports (if relevant) reference points in lane mark: lateral position of lane mark at reference point and physical distance of ref point from camera
In this document, when mentioning lateral distance from vehicle or lateral location in reference to vehicle, positive direction is right.

Term	Description
LKA	Lane Keeping and Guidance Assist
byte 1	MSB
byte 0	LSB
Unsigned	As Canalyzer defines unsigned in a dbc file

- The message is transmitted in an 11bit CAN header format.
- The baud rates are configurable (250, 500 or 1000kbps). Default baud rate is 500Kbps
- The CAN message is transmitted approximately every 66-100 ms.

8.2.4.1 Messages overview

The following messages are supported by LKA common CAN protocol:

Message	Code	Description
LKA left lane A	0x766	Left lane type validity and position Left lane Curvature and Curvature Derivative
LKA left lane B	0x767	Left lane heading, view range signal
LKA right lane A	0x768	Right lane type validity and position Right lane Curvature and Curvature Derivative
LKA right lane B	0x769	Right lane heading, view range signal
Reference points	0x76a	Reference points position and distance
Numebr of next lane markers reported	0x76b	
Next lane A	0x76C +2*N (N=[0,..,8]	Next lane n for N = [0, .., 1] Lane type, validity, position, curvature and curvature derivative
Next lane B	0x76D +2*N (N=[0,..,8]	Next lane n for N = [0, .., 1] Lane heading angle and view range

8.2.4.2 CAN Message 0x766 Details – LKA left lane A

Bit	7(MSB)	6	5	4	3	2	1	0(LSB)
Byte 0	Model degree		Quality		Lane type			
Byte 1	Position Parameter C0 byte 0							
Byte 2	Position Parameter C0 Byte 1							
Byte 3	Curvature Parameter C2 byte 0							
Byte 4	Curvature Parameter C2 byte 1							
Byte 5	Curvature derivative Parameter C3 byte 0							
Byte 6	Curvature derivative Parameter C3 byte 1							
Byte 7	Width left marking							

8.2.4.2.1 Lane type

- Type: ENUM
- Meaning:
  - 0 – dashed
  - 1 – solid
  - 2 – undecided
  - 3 – road edge
  - 4 – double lane mark (including dashed on one side)
  - 5 – Botts' dots
  - 6 – invalid

8.2.4.2.2 Quality

- Type: ENUM
- Meaning:
  - 0,1 – low quality. The lane measurements are not valid in low quality. The system will not give an LDW in that situation.
  - 2,3 – high quality

8.2.4.2.3 Model degree

- Type: ENUM
- Meaning:
  - 1 – linear model
  - 2 – parabolic model
  - 3 – 3rd-degree model

8.2.4.2.4 Position Parameter C0

- Type: signed 16 bits
- Meaning: physical distance between lane mark and camera on the lateral position. Also parameter C0 of polynomial model [see chapter 3]
- Decode: Position = HEX / 256
- Range: [-127 - 128]
- Unit: meter

8.2.4.2.5 Curvature Parameter C2

- Type: unsigned 16 bits
- Meaning: parameter C2 of polynomial model [see chapter 3 on how to calculate curvature from this parameter]Direction: given a very low curvature derivative, positive curvature indicates a right hand side curve (as can be learned from the formula in chapter 3)
- Decode: curvature = (HEX – 0x7FFF)/1024/1000
- Range: [-0.02 – 0.02]
- Unit: n/a
- To extract the road radius (r) from curvature (C2): r = 1/(2*C2)

8.2.4.2.6 Curvature derivative Parameter C3

- Type: unsigned 16 bit
- Meaning: parameter C3 of polynomial model [see chapter 3 on how to calculate curvature derivative from this parameter]
- Decode: derivative = (HEX – 0x7FFF)/(1<<28)
- Range: [-0.00012 – 0.00012]
- Unit: n/a

8.2.4.2.7 Width left marking

- Type: unsigned 8 bit
- Meaning: Left lane marking width
- Decode: Hex * 0.01
- Range: [0 – 2.5]
- Unit

8.2.4.3 Can Message 0x767 Details – LKA left lane B

Bit	7(MSB)	6	5	4	3	2	1	0(LSB)
Byte 0	Heading angle byte 0							
Byte 1	Heading angle byte 1							
Byte 2	View range LSB							
Byte 3	View range availability	View range MSB						
Byte 4	Reserve							
Byte 5	Reserve							
Byte 6	Reserve							
Byte 7	Reserve							

8.2.4.3.1 Heading angle Parameter C1

- Type: unsigned 16 bits
- Meaning: physical slope of the lane mark [parameter C1 of polynomial model on chapter 3]
- Direction: positive means steering towards the right
- Decode: slope = (HEX – 0x7FFF) / 1024
- Range: [-0.357 - 0.357]
- Unit: radians

8.2.4.3.2 View Range

- Type: unsigned 15 bits
- Meaning: physical view range of lane mark
- Decode: range = HEX/256
- Range: [0 – 127.996].
- Unit: meter
- The value is valid only when the appropriate quality>1

8.2.4.3.3 View range availability

- Type: ENUM
- Meaning;
  - 0 – not valid
  - 1 – valid

8.2.4.4 CAN Message 0x768 Details – LKA right lane A

Bit	7(MSB)	6	5	4	3	2	1	0(LSB)
Byte 0	Model degree		Quality		Lane type			
Byte 1	Position Parameter C0 byte 0							
Byte 2	Position Parameter C0 Byte 1							
Byte 3	Curvature Parameter C2 byte 0							
Byte 4	Curvature Parameter C2 byte 1							
Byte 5	Curvature derivative Parameter C3 byte 0							
Byte 6	Curvature derivative Parameter C3byte 1							
Byte 7	Width right marking							

8.2.4.4.1 Lane type

- Type: ENUM
- Meaning:
  - 0 – dashed
  - 1 – solid
  - 2 – undecided
  - 3 – road edge
  - 4 – double lane mark (including dashed on one side)
  - 5 – Botts' dots
  - 6 – invalid

8.2.4.4.2 Quality

- Type: ENUM
- Meaning:
  - 0,1 – low quality. The lane measurements are not valid in low quality. The system will not give an LDW in that situation.
  - 2,3 – high quality

8.2.4.4.3 Model degree

- Type: ENUM
- Meaning:
  - 1 – linear model
  - 2 – Parabolic model
  - 3 – 3-degree model

8.2.4.4.4 Position Parameter C0

- Type: signed 16 bits
- Meaning: physical distance between lane mark and camera on the lateral position. Also parameter C0 of polynomial model [see chapter 3]
- Decode: Position = HEX / 256

- Range: [-127 – 128]
- Unit: meter

8.2.4.4.5 Curvature Parameter C2

- Type: unsigned 16 bits
- Meaning: parameter C2 of polynomial model [see chapter 3 on how to calculate curvature from this parameter]
- Direction: given a very low curvature derivative, positive curvature indicates a right hand side curve (as can be learned from the formula in chapter 3)
- Decode: curvature = (HEX – 0x7FFF)/1024/1000
- Range: [-0.02 – 0.02]
- Unit: n/a
- To extract the road radius (r) from curvature (2): r = 1/(2*C2)

8.2.4.4.6 Curvature derivative Parameter C3

- Type: unsigned 16 bit
- Meaning: parameter C3 of polynomial model [see chapter 3 on how to calculate curvature derivative from this parameter]
- Decode: derivative = (HEX – 0x7FFF)/(1<<28)
- Range: [-0.00012 – 0.00012]
- Unit: n/a

8.2.4.4.7 Width right marking

- Type: unsigned 8 bit
- Meaning: Right lane marking width
- Decode: Hex * 0.01
- Range: [0 – 2.5]
- Unit: m

8.2.4.5 Can Message 0x769 Details – LKA right lane B

Bit	7(MSB)	6	5	4	3	2	1	0(LSB)
Byte 0	Heading angle Parameter C1 byte 0							
Byte 1	Heading angle Parameter C1 byte 1							
Byte 2	View range LSB							
Byte 3	View range availability	View range MSB						
Byte 4	Reserve							
Byte 5	Reserve							
Byte 6	Reserve							
Byte 7	Reserve							

8.2.4.5.1 Heading angle Parameter C1

- Type: unsigned 16 bits
- Meaning: physical slope of the lane mark [parameter C1 of polynomial model on chapter 3]
- Direction: positive means steering towards the right
- Decode: slope = (HEX – 0x7FFF) / 1024
- Range: [-0.357 - 0.357]
- Unit: radians

8.2.4.5.2 View Range

- Type: unsigned 15 bits
- Meaning: physical view range of lane mark
- Decode: range = HEX/256
- Range: [0 – 127.996].
- Unit: meter
- The value is valid only when the appropriate quality>1

8.2.4.5.3 View range availability

- Type: ENUM
- Meaning;
  - 0 – not valid
  - 1 - valid

8.2.4.6 CAN Message 0x76a Details – Reference points

Bit	7(MSB)	6	5	4	3	2	1	0(LSB)
Byte 0	Ref point 1 Position byte 0							
Byte 1	Ref point 1 Poistion byte 1							
Byte 2	Ref point 1 Distance byte 0							
Byte 3	Ref point 1 validity	Ref point 1 Distance byte 1						
Byte 4	Ref point 2 Position byte 0							
Byte 5	Ref point 2 Poistion byte 1							
Byte 6	Ref point 2 Distance byte 0							
Byte 7	Ref point 1 validity	Ref point 2 Distance byte 1						

Please note: First ref' point should reflect the 1sec' ahead, middle of road infront. The rest of the reference points are currently not in use and they are located in protocol as place holders.

8.2.4.6.1 Ref point 1 Position

- Type: unsigned 16 bits
- Meaning: physical distance between camera and reference point 1 on lateral axis. The reference point defines the lateral location of the lane center at ref-Point distance (for example lane center is 0.6m to the right at 35m from the camera) . Ref Point 1 is this measurement at 1 second headway.
- Decode: Position = (HEX – 0x7FFF) / 256
- Range: [-127.996 – 127.996]
- Unit: meters

8.2.4.6.2 Ref point 1 Distance

- Type: unsigned 15 bits
- Meaning: physical distance between reference point and camera see definition at 2.1.5.1
- Decode: HEX / 256
- Range: [0 – 127.99609376]
- Unit: meters

8.2.4.6.3 Ref point 1 Validity

- Type: ENUM
- Meaning: reference point 1 validity.
  - 0 – invalid
  - 1 – valid

8.2.4.6.4 Ref point 2 Position

- Type: unsigned 16 bits
- Meaning: Empty . physical distance between camera and reference point on lateral axis. The reference point defines the lateral location of the lane center at ref-Point distance (for example lane center is 0.6m to the right at 35m from the camera)
- Decode: Position = (HEX - 0x7FFF)/ 256
- Range: [-127.996 – 127.996]
- Unit: meters

8.2.4.6.5 Ref point 2 Distance

- Type: unsigned 15 bits
- Meaning: Empty . physical distance between reference point and camera
- Decode: HEX / 256
- Range: [0 – 127.99609376]
- Unit: meters

8.2.4.6.6 Ref point 1 Validity

- Type: ENUM
- Empty . Meaning: reference point 2 validity.
    - 0 – invalid
    - 1 – valid

8.2.4.7 CAN Message 0x76B Details – number of next lane markers reported

Bit	7(MSB)	6	5	4	3	2	1	0(LSB)
Byte 0	Number of next lane markers reported							
Byte 1	Reserve							
Byte 2	Reserve							
Byte 3	Reserve							
Byte 4	Reserve							
Byte 5	Reserve							
Byte 6	Reserve							
Byte 7	Reserve							

8.2.4.7.1 Number of next lane markers reported

- Type: unsigned int
  Meaning: indicates how many extra lane markers are also reported, on top of left and right lane. Currently two lane marks are always reported one for left and one for right, and they are valid only if the lane type is Solid.

  Each next lane marker is defined by 2 message IDs.

  0x76C & 0x76D + 4N (N=0..3) will be for the left lane.
  0x76E & 0x76F + 4N (N=0..3) will be for the right lane.

*8.2.4.8 CAN Message 0x76C + 2*N (N = [0, .., 7] Details – next lane A*

Bit	7(MSB)	6	5	4	3	2	1	0(LSB)
Byte 0	Model degree		Quality		Lane type			
Byte 1	Position Parameter C0 Byte 0							
Byte 2	Position Parameter C0 Byte 1							
Byte 3	Curvature Parameter C2 byte 0							
Byte 4	Curvature Parameter C2 byte 1							
Byte 5	Curvature derivative Parameter C3 byte 0							
Byte 6	Curvature derivative Parameter C3 byte 1							
Byte 7	Lane mark width							

8.2.4.8.1 Lane type

- Type: ENUM
- Meaning:
  - 1 – solid
  - 2 – undecided

Remark: Currently we only support solid as lane type, and undecided when we do not recognize the lane type.

8.2.4.8.2 Quality

Remark: Not yet implemented for next lanes.

8.2.4.8.3 Model degree

- Type: ENUM
- Meaning:
  - 1 – linear model
  - 2 – parabolic model
  - 3 – 3rd-degree model

8.2.4.8.4 Position Parameter C0

- Type: signed 16 bits
- Meaning: physical distance between lane marl and camera on the lateral position. Also parameter C0 of polynomial model [see chapter 3]
- Decode: Position = HEX / 256
- Range: [-127 – 128]
- Unit: meter

8.2.4.8.5 Curvature Parameter C2

- Type: unsigned 16 bits
- Meaning: parameter C2 of polynomial model [see chapter 3 on how to calculate curvature from this parameter]
- Direction: given a very low curvature derivative, positive curvature indicates a right hand side curve (as can be learned from the formula in chapter 3)
- Decode: curvature = (HEX – 0x7FFF)/1024/1000
- Range: [-0.02 – 0.02]
- Unit: n/a
- To extract the road radius (r) from curvature (C2): r = 1/(2*C2)

8.2.4.8.6 Curvature derivative Parameter C3

- Type: unsigned 16 bit
- Meaning: parameter C3 of polynomial model [see chapter 3 on how to calculate curvature derivative from this parameter]
- Decode: derivative = (HEX – 0x7FFF)/(1<<28)
- Range: [-0.00012 – 0.00012]
- Unit: n/a

8.2.4.8.7 Lane mark width

- Type: unsigned 8 bit
- Meaning: Lane marking width
- Decode: Hex * 0.01
- Range: [0 – 2.5]
- Unit: m

*8.2.4.9 Can Message 0x76D + 2*N (N = [0, .. , 8]) Details – next lane B*

Bit	7(MSB)	6	5	4	3	2	1	0(LSB)
Byte 0	Heading angle Parameter C1 byte 0							
Byte 1	Heading angle Parameter C1 byte 1							
Byte 2	View range LSB							
Byte 3	View range availability	View range MSB						
Byte 4	Reserve							
Byte 5	Reserve							
Byte 6	Reserve							
Byte 7	Reserve							

8.2.4.9.1 Heading angle Parameter C1

- Type: unsigned 16 bits
- Meaning: physical slope of the lane mark [parameter C1 of polynomial model on chapter 3]
- Direction: positive means steering towards the right
- Decode: slope = (HEX – 0x7FFF) / 1024
- Range: [-0.357 - 0.357]
- Unit: radians

8.2.4.9.2 View Range

Remark: Currently not available for next lanes.

8.2.4.9.3 View range availability

- Type: ENUM
- Meaning;
  - 0 – not valid
  - 1 – vali

8.2.4.10 Formulation

8.2.4.10.1 Naming convention

Z – Physical longitudinal distance from camera
X – Psychical lateral offset from Camera
C0 – Lane position parameter at Z=0 (see 8.2.4.2.4 & 8.2.4.4.4 & 8.2.4.8.4)
C1 – Heading angle parameter at Z=0 (see 8.2.4.3.1 & 8.2.4.5.1 & 8.2.4.8.1)
C2 – Lane curvature parameter at Z=0 (see 8.2.4.2.5 & 8.2.4.4.5 & 8.2.4.8.5)
C3 – Lane curvature derivative parameter at Z=0 (see 8.2.4.2.6 & 8.2.4.4.6 & 8.2.4.8.6)

ME is modeling each lane marker (or line) with a 3rd degree polynomial model that describes a function X(Z), where Z is the real world longitudinal distance from camera and X is the real world lateral distance from the camera ("real world" is used to distinguish it from image measurement in [pixels]). For example, given such a line model, one is capable of asking "At what lateral distance (X) lies the line with respect to a point Z=40m directly in front of the camera?"

The following formula could be used to derive the lateral distance of the lane at a given distance.

Right side is the positive direction.

8.3 Formulas

- Deriving lateral distance from longitudes distance:

$$X = C3 \cdot Z^3 + C2 \cdot Z^2 + C1 \cdot Z + C0$$

- Lane marker curvature at distance Z:

$$curvature(Z) = 2 \cdot C2 + 6 \cdot C3 \cdot Z$$

C0 - Lane Position(Z=0) = C0 [meters]

C1 - Heading Angle(Z=0) = arctan(C1) ~= C1 [radian]

C2 - Lane Curvature(Z=0) : 2*C2 [1/m]

C3 - Lane Curvature Derivative(Z): 6*C3 [1/m^2]

ME is providing one set of coefficients per line.
From that polynomial you can derive the actual heading angle, curvature and curvature rate (or curvature derivative) of the lane marker itself:

8.3.1.1.1 Heading angle:

- heading_angle(Z) = arctan(dX/dZ) ~= dX/dZ (small angle estimation ; accurate to 99% for all practical angle spectrum)
- heading_angle(Z) ~= dX(Z)/dZ = 3*C3*Z^2 + 2*C2*Z + C1.
  However, usually one is interested in heading angle at camera meaning at Z=0
- heading_angle(Z=0) = C1
  (in other words the protocol's heading angle parameter C1 is a very good estimator of vehicle heading angle with respect to lane marker at camera line)
- If you are looking forward, and the angle is 0.5 Rad, you will see that the left lane mark is getting closer to you. If the angle will be negative, you will see that the left lane mark is going away from you.

8.3.1.1.2 Curvature:

- curvature(Z) = (dX(Z)/dZ) / dZ = d^2X(Z)/d^2Z = 6*C3*Z + 2*C2.
- Again, one might be interested only in the lane curvature at camera line (Z = 0). In that case, the curvature take the following form:
- curvature(Z=0) = 2*C2
  or protocol value "curvature" equals 1/2 of actual curvature are camera line.
- Nevertheless, a sophisticated LKA implementation would probably like to know also the curvature reading at some distance other than Z=0m in front of the car, say at wheels line (Z~=1m) or 5m in front of the vehicle (Z=5m). That is especially important if the road takes a "S" shape, e.g. curving to the right at camera line, but curving to the left somewhere in front of vehicle.

8.3.1.1.3 Curvature Rate/Derivative :

curvature_rate = d^3X(Z)/d^3Z = 6*C3
or protocol value "curvature derivative" equals 1/6 of actual curvature rate.

8.3.1.1.4 Coordinate System

The ME coordinate system is as follows:
(0,0) is at FOE; Y grows UPWARDS, as appose to conventional (vision) systems where Y grows DOWNWARDS.

Measurements are with respect to camera, are in real world (that is meters and not pixels) and coordinate system follow the normal directions (X, Y, Z for lateral, vertical and longitudinal, respectively)

Angles are positive to the right, and negative to the left.