

Functional Safety Concept Lane Assistance

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# Document history

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| --- | --- | --- | --- |
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| 2017-10-22 | 1.0 | Martin Hintz | Initial version |
| 2017-10-30 | 1.1 | Martin Hintz | Layout and spelling corrections |
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# Purpose of the Functional Safety Concept

This document provides a functional safety concept to avoid accidents by reducing risks involved in the Lane Assistance functionality to acceptable levels.

# Inputs to the Functional Safety Concept

## Safety goals from the Hazard Analysis and Risk Assessment

|  |  |
| --- | --- |
| **ID** | **Safety Goal** |
| Safety\_Goal\_01 | The steering torque applied from the Lane Departure Warning functionality shall be limited. |
| Safety\_Goal\_02 | The Lane Assistance functionality shall be time limited and the additional steering torque shall end after a pre-defined time interval so that the drive. |

## Preliminary Architecture

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Figure 1: Preliminary Architecture of the Lane Assistance System

### Description of architecture elements

|  |  |
| --- | --- |
| **Element** | **Description** |
| Camera Sensor | One or more sensor(s) located at the front of  the vehicle that collect(s) visual data (image, video) |
| Camera Sensor ECU | A computer (electronic control unit) that interprets data collected by the camera sensor(s), detects lane lines, identifies and calculates steering corrections, triggers power steering ECU and triggers audio-visual warnings on the car display ECU. |
| Car Display | A physical display in front of the vehicle’s driver to provide audio-visual feedback. |
| Car Display ECU | A computer (ECU) that controls the car display and generates audio-visual warnings triggered from camera sensor ECU. |
| Driver Steering Torque Sensor | A sensor that measures the torque applied to the steering wheel by the driver. |
| Electronic Power Steering ECU | A computer attached to the power steering of the vehicle that controls the torque applied to the steering wheel according to the commands of the camera sensor ECU. |
| Motor | An actuator responsible for applying torque to the steering wheel. |

# Functional Safety Concept

The functional safety concept consists of:

* Functional safety analysis
* Functional safety requirements
* Functional safety architecture
* Warning and degradation concept

## Functional Safety Analysis

|  |  |  |  |
| --- | --- | --- | --- |
| **Malfunction ID** | **Main Function of the Item Related to Safety Goal Violations** | **Guidewords (NO, WRONG, EARLY, LATE, MORE, LESS)** | **Resulting Malfunction** |
| Malfunction\_01 | Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback | MORE | The lane departure warning function applies an oscillating torque with very high torque amplitude (above limit Max\_Torque\_Amplitude). |
| Malfunction\_02 | Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback | MORE | The lane departure warning function applies an oscillating torque with very high torque frequency (above limit Max\_Torque\_Frequency). |
| Malfunction\_03 | Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane | NO | The lane keeping assistance function is not limited in time duration, which leads to misuse as an autonomous driving function. |

## Functional Safety Requirements

Lane Departure Warning (LDW) Requirements:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Functional Safety Requirement** | **ASIL** | **Fault Tolerant Time Interval** | **Safe State** |
| Functional  Safety  Requirement  01-01 | The Electronic Power Steering ECU shall ensure that the lane departure warning oscillating torque amplitude is below Max\_Torque\_Amplitude | C | 50 ms | Turn Off System |
| Functional  Safety  Requirement  01-02 | The Electronic Power Steering ECU shall ensure that the lane departure warning oscillating torque frequency is below Max\_Torque\_Frequency | C | 50 ms | Turn Off System |

Lane Departure Warning (LDW) Verification and Validation Acceptance Criteria:

|  |  |  |
| --- | --- | --- |
| **ID** | **Validation Acceptance**  **Criteria and Method** | **Verification Acceptance**  **Criteria and Method** |
| Functional  Safety  Requirement  01-01 | Test that the amplitude value chosen for  Max\_Torque\_Amplitude is balanced and does not trigger counter actions from the driver. | Verify that LDW is turned off when Max\_Torque\_Amplitude is exceeded and a warning is being generated. |
| Functional  Safety  Requirement  01-02 | Test that the amplitude value chosen for  Max\_Torque\_Frequency is balanced and does not trigger counter actions from the driver. | Verify that LDW is turned off when Max\_Torque\_Frequency is exceeded and a warning is being generated. |

Lane Keeping Assistance (LKA) Requirements:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Functional Safety Requirement** | **ASIL** | **Fault Tolerant Time Interval** | **Safe State** |
| Functional  Safety  Requirement  02-01 | The electronic power steering ECU  shall ensure that the lane keeping  assistance torque is applied for only  Max\_Duration. | B | 500 ms | Turn Off System |

Lane Keeping Assistance (LKA) Verification and Validation Acceptance Criteria:

|  |  |  |
| --- | --- | --- |
| **ID** | **Validation Acceptance**  **Criteria and Method** | **Verification Acceptance**  **Criteria and Method** |
| Functional  Safety  Requirement  02-01 | Test that the time value chosen for Max\_Duration discourages drivers from taking their hands off the steering wheel. | Verify that LKA is turned off when Max\_Duration is exceeded and a warning is being generated. |

## Refinement of the System Architecture



Figure 2: Refined Architecture of the Lane Assistance System

## Allocation of Functional Safety Requirements to Architecture Elements

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Functional Safety Requirement** | **Electronic Power Steering ECU** | **Camera ECU** | **Car Display ECU** |
| Functional  Safety  Requirement  01-01 | The electronic power steering ECU shall ensure shall ensure that the oscillating torque amplitude is below Max\_Torque\_Amplitude for the lane departure warning item. | X |  |  |
| Functional  Safety  Requirement  01-02 | The electronic power steering ECU shall ensure shall ensure that the oscillating torque frequency is below Max\_Torque\_Frequency for the lane departure warning item. | X |  |  |
| Functional  Safety  Requirement  02-01 | The electronic power steering ECU shall ensure that the lane keeping assistance torque is applied for only Max\_Duration. | X |  |  |

## Warning and Degradation Concept

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Degradation Mode** | **Trigger for Degradation Mode** | **Safe State invoked?** | **Driver Warning** |
| WDC-01 | Turn off the functionality. | Malfunction\_01  Malfunction\_02 | Yes | Audio-Visual Warning in Car Display |
| WDC-02 | Turn off the functionality. | Malfunction\_03 | Yes | Audio-Visual Warning in Car Display |