

Technical Safety Concept Lane Assistance

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# Document history

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# Table of Contents

Inhalt

[Document history 2](#_Toc495585883)

[Table of Contents 2](#_Toc495585884)

[Purpose of the Technical Safety Concept 3](#_Toc495585885)

[Inputs to the Technical Safety Concept 3](#_Toc495585886)

[Functional Safety Requirements 3](#_Toc495585887)

[Refined System Architecture from Functional Safety Concept 4](#_Toc495585888)

[4](#_Toc495585889)

[Functional overview of architecture elements 4](#_Toc495585890)

[Technical Safety Concept 5](#_Toc495585891)

[Technical Safety Requirements 5](#_Toc495585892)

[Refinement of the System Architecture 10](#_Toc495585893)

[Allocation of Technical Safety Requirements to Architecture Elements 11](#_Toc495585894)

[Warning and Degradation Concept 11](#_Toc495585895)

# Purpose of the Technical Safety Concept

This document derives the functional safety requirements from the safety goals, and allocates them to an architectural element. This will delineate the hardware and software architecture as well as the safety mechanisms to be implemented.

# Inputs to the Technical Safety Concept

## Functional Safety Requirements

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Functional Safety Requirement** | **ASIL** | **Fault Tolerant Time Interval** | **Safe State** |
| Functional  Safety  Requirement  01-01 | The electronic power steering ECU shall limit the alert for the LDW, so the amplitude of the oscillating torque is less than Max\_Torque\_Amplitude | C | 50ms | LDW requested torque is set to zero.  The failure is shown in the car display and recorded. |
| Functional  Safety  Requirement  01-02 | The electronic power steering ECU shall limit the alert for the LDW, so the frequency of the oscillating torque is less than Max\_Torque\_Frequency | C | 50ms | LDW requested torque is set to zero.  The failure is shown in the car display and recorded. |
| Functional  Safety  Requirement  02-01 | The power steering ECU shall limit the duration of the functionality up to a period of Max\_Duration | B | 500ms | LKA requested torque is zero. |

## Refined System Architecture from Functional Safety Concept

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### Functional overview of architecture elements

|  |  |
| --- | --- |
| **Element** | **Description** |
| Camera Sensor | Obtains the image as raw data. |
| Camera Sensor ECU - Lane Sensing | Extract the lane lines and calculates the if the vehicle is inside the lane. |
| Camera Sensor ECU - Torque request generator | With the information of the Lane Sensing ECU, calculates the torque needed to keep the lane and correct the deviation. Then communicates with the electronic power steering ECU. |
| Car Display | Shows information about the state of the system:   * System active/inactive * Lane assist on-line/off-line * Lane assist malfunction |
| Car Display ECU - Lane Assistance On/Off Status | Indicates that the Lane Assistance is not enabled. |
| Car Display ECU - Lane Assistant Active/Inactive | Indicates whether the system is correcting the direction of the vehicle or is just passive at the moment but ready. |
| Car Display ECU - Lane Assistance malfunction warning | If this lamp is active the lane assistance system was found faulty by itself or by another unit. |
| Driver Steering Torque Sensor | This sensor gives feedback on the force applied to the steering wheel. |
| Electronic Power Steering (EPS) ECU - Driver Steering Torque | Processes the messages from the torque sensor and sends the required torque to achieve the requested torque if it is within the limits. |
| EPS ECU - Normal Lane Assistance Functionality | Processes the nominal signals from the camera subsystem which are not safety relevant. |
| EPS ECU - Lane Departure Warning Safety Functionality | Imposes the limits in frequency and amplitude to the received signal. |
| EPS ECU - Lane Keeping Assistant Safety Functionality | Ensures the limited span of time in the functionality of the LKA system. |
| EPS ECU - Final Torque | This functionality is the responsible of monitor and ensure the correctness of the requested torque. If the requested torque is out of limits a failure is set. |
| Motor | Provides the physical result in the system, which is the torque being applied in the steering column. |

# Technical Safety Concept

## Technical Safety Requirements

**Lane Departure Warning (LDW) Requirements:**

Functional Safety Requirement 01-01 with its associated system elements

(derived in the functional safety concept)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Functional Safety Requirement** | **Electronic Power Steering ECU** | **Camera ECU** | **Car Display ECU** |
| Functional  Safety  Requirement  01-01 | The lane keeping item shall ensure that the lane departure oscillating torque amplitude is below Max\_Torque\_Amplitude | X |  |  |

Technical Safety Requirements related to Functional Safety Requirement 01-01 are:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **ID** | **Technical Safety Requirement** | **ASIL** | **Fault Tolerant Time Interval** | **Architecture Allocation** | **Safe State** |
| Technical  Safety  Requirement  01 | The LDW safety component shall ensure that the amplitude of the 'LDW\_Torque\_Request' sent to the 'Final electronic power steering Torque' component is below 'Max\_Torque\_Amplitude. | C | 50ms | Power Steering ECU – here the LDW safety block shall be implemented. | LDW functionality set off and requested torque set to 0. |
| Technical  Safety  Requirement  02 | As soon as the LDW function deactivates the LDW feature, the 'LDW Safety' software block shall send a signal to the car display ECU to turn on a warning light. | C | 50ms | Power Steering ECU – here the LDW safety block shall be implemented. | LDW functionality set off and requested torque set to 0. |
| Technical  Safety  Requirement  03 | As soon as a failure is detected by the LDW function, it shall deactivate the LDW feature and the 'LDW\_Torque\_Request' shall be set to zero. | C | 50ms | Power Steering ECU – here the LDW safety block shall be implemented. | LDW functionality set off and requested torque set to 0. |
| Technical  Safety  Requirement  04 | The validity and integrity of the safety data signal ‘LDW\_Torque\_Request‘ shall be ensured. | C | 50ms after faulty message | Power Steering ECU – The communication stack of this ECU | LDW functionality set off and requested torque set to 0. (Unknowns state of the system) |
| Technical  Safety  Requirement  05 | Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory. | A | Duration of ignition cycle | ECU bootloader | LDW functionality set off and requested torque set to 0. |

Functional Safety Requirement 01-2 with its associated system elements

(derived in the functional safety concept)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Functional Safety Requirement** | **Electronic Power Steering ECU** | **Camera ECU** | **Car Display ECU** |
| Functional  Safety  Requirement  01-02 | The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max\_Torque\_Frequency | X |  |  |

Technical Safety Requirements related to Functional Safety Requirement 01-02 are:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **ID** | **Technical Safety Requirement** | **ASIL** | **Fault Tolerant Time Interval** | **Architecture Allocation** | **Safe State** |
| Technical  Safety  Requirement  01 | The LDW safety component shall  ensure that the frequencies of the 'LDW\_Torque\_Request' sent to the 'Final electronic power steering Torque' component is below 'Max\_Torque\_Frequency. | C | 50ms | Power Steering ECU -- here the LDW safety block shall be implemented | LDW functionality set off and requested torque set to 0. |
| Technical  Safety  Requirement  02 | As soon as the LDW function deactivates the LDW feature, the 'LDW Safety' software block shall send a signal to the car display ECU to turn on a warning light. | C | 50ms | Power Steering ECU. -- here the LDW safety block shall be implemented | LDW functionality set off and requested torque set to 0 |
| Technical  Safety  Requirement  03 | As soon as a failure is detected by the LDW function, it shall deactivate the LDW feature and the 'LDW\_Torque\_Request' shall be set to zero. | C | 50ms | Power Steering ECU. -- here the LDW safety block shall be implemented | LDW functionality set off and requested torque set to 0 |
| Technical  Safety  Requirement  04 | The validity and integrity of the data transmission for 'LDW\_Torque\_Request' signal shall be ensured. | C | 50ms | Power Steering ECU – The communication stack of this ECU | LDW functionality set off and requested torque set to 0. (Unknowns state of the system) |
| Technical  Safety  Requirement  05 | Memory test shall be conducted at start-up of the EPS ECU to check for any faults in memory | A | Duration of the ignition cycle | Power Steering ECU bootloader | LDW functionality set off and requested torque set to 0. (Unknowns state of the system) |

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

**Lane Keeping Assistance (LKA) Requirements:**

Functional Safety Requirement 02-1 with its associated system elements

(derived in the functional safety concept)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Functional Safety Requirement** | **Electronic Power Steering ECU** | **Camera ECU** | **Car Display ECU** |
| Functional  Safety  Requirement  02-01 | The lane keeping item shall ensure that the lane keeping assistance torque is applied for only Max\_Duration | X |  |  |

Technical Safety Requirements related to Functional Safety Requirement 02-01 are:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **ID** | **Technical Safety Requirement** | **ASIL** | **Fault Tolerant Time Interval** | **Allocation to Architecture** | **Safe State** |
| Technical  Safety  Requirement  01 | The safety block for the LKA shall ensure that the functionality is active for a Max\_Duration at most. | B | 500 ms | Power Steering ECU – The safety LKA block | LKA functionality set off and requested torque set to 0. |
| Technical  Safety  Requirement  02 | As soon as a failure in the LKA is detected, the functionality shall be deactivated, then the safety block shall send a signal to the display ECU to turn-on the failure lamp. | B | 500ms | Power Steering ECU – The safety LKA block | LKA functionality set off and requested torque set to 0. |
| Technical  Safety  Requirement  03 | As soon as a failure is detected by the LKA function, it shall deactivate the LKA feature and  the 'LKA\_Torque\_Request' shall be set to zero. | B | 500ms | Power Steering ECU – The safety LKA block | LKA functionality set off and requested torque set to 0. |
| Technical  Safety  Requirement  04 | The validity and integrity of the data transmission for 'LKA\_Torque\_Request' signal shall be ensured. | B | 500ms | Power Steering ECU – The safety LKA block | LKA functionality set off and requested torque set to 0. (Unknowns state of the system) |
| Technical  Safety  Requirement  05 | Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory. | A | Duration of the ignition cycle | ECU bootloader | LKA functionality set off and requested torque set to 0. Software is not reliable. |

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

## Refinement of the System Architecture

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## Allocation of Technical Safety Requirements to Architecture Elements

## Warning and Degradation Concept

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Degradation Mode** | **Trigger for Degradation Mode** | **Safe State invoked?** | **Driver Warning** |
| WDC-01 | LDW functionality is deactivated and lamp turned on. | Requested oscillation amplitude is > Max\_Torque\_Amplitude OR Requested oscillation frequency is > Max\_Torque\_Frequency | Yes | Yes, through lamp in the dash board. |
| WDC-02 | LKA functionality is deactivated and lamp turned on. | LKA functionality is active after Max\_Duration | Yes | Yes, through lamp in the dash board. |