

Technical Safety Concept Lane Assistance

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# Document history

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# Purpose of the Technical Safety Concept

The purpose of Technical Safety Concept is:

* Turning functional safety requirements into technical safety requirements.
* Allocating technical safety requirements to the system architecture.

These new requirements are more concrete and gets into details of the item’s technology as specified by ISO 26262.

# 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 Lane Departure Warning item shall ensure that the lane departure oscillating torque amplitude is below Max\_Torque\_Amplitude. | C | 50 ms | Vibration torque amplitude below Max\_Torque\_Amplitude. |
| Functional  Safety  Requirement  01-02 | The Lane Departure Warning item shall ensure that the lane departure oscillating torque frequency is below Max\_Torque\_Frequency. | C | 50 ms | Vibration frequency is below Max\_Torque\_Frequency. |
| Functional  Safety  Requirement  02-01 | The electronic power steering ECU shall ensure that the Lane Keeping Assistance torque is applied only Max\_Duration. | B | 500 ms | Lane Keeping Assistance torque is zero. |

## Refined System Architecture from Functional Safety Concept



### Functional overview of architecture elements

|  |  |
| --- | --- |
| **Element** | **Description** |
| Camera Sensor | Capture road images and provide them to the Camera Sensor ECU. |
| Camera Sensor ECU - Lane Sensing | Software module detecting the lane line positions from the Camera Sensor images. |
| Camera Sensor ECU - Torque request generator | Software module calculating the necessary torque to be requested to the Electronic Power Steering ECU. |
| Car Display | Display warning for the driver. |
| Car Display ECU - Lane Assistance On/Off Status | Indicate the status of the Lane Assistance functionality (On/Off.) |
| Car Display ECU - Lane Assistant Active/Inactive | Indicate if the Lane Assistance functionality is properly functioning (Active/Inactive.) |
| Car Display ECU - Lane Assistance malfunction warning | Indicate a malfunction on the Lane Assistance functionality. |
| Driver Steering Torque Sensor | Measure the torque applied to the steering wheel by the driver. |
| Electronic Power Steering (EPS) ECU - Driver Steering Torque | Software module receiving the driver’s torque request from the steering wheel. |
| EPS ECU - Normal Lane Assistance Functionality | Software module receiving the Camera Sensor ECU torque request. |
| EPS ECU - Lane Departure Warning Safety Functionality | Software module ensuring the torque amplitude is below Max\_Torque\_Amplitude and torque frequency is below Max\_Torque\_Frequency. |
| EPS ECU - Lane Keeping Assistant Safety Functionality | Software module ensuring the Lane Keeping Assistance functionality application is not activate more than Max\_duration time. |
| EPS ECU - Final Torque | Combine the torque request from the Lane Keeping and Lane Departure Warning functionalities and sends them to the Motor. |
| Motor | Applies the required torque to the steering wheels. |

# 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 Lane Departure Warning 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 | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |
| Technical  Safety  Requirement  02 | When the Lane Departure Warning is deactivated, the ‘LDW Safety’ software module shall send a signal to the Car Display ECU to turn on a warning signal. | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |
| Technical  Safety  Requirement  03 | When a failure is detected by the Lane Departure Warning functionality, it shall deactivate the Lane Departure Warning feature and set ‘LDW\_Torque\_Request’ to zero. | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |
| Technical  Safety  Requirement  04 | The validity and integrity of the data transmission for ‘LDW\_Torque\_Request’ signal shall be ensured. | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |
| Technical  Safety  Requirement  05 | Memory test shall be conducted at startup of the EPS ECU to check for any memory problems | A | Ignition cycle | Data Transmission Integrity Check | Lane Departure Warning torque to zero. |

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 frequency of ‘LDW\_Frequency\_Request’ sent to ‘Final electronic power steering torque’ component is below Max\_Trorque\_Frequency | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |
| 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 | 50 ms | LDW safety functionality | Deactivate functionality (reset frequency to 0) |
| Technical  Safety  Requirement  03 | As soon as the failure is detected by the LDW function, it shall deactivate the LDW feature and ‘LDW\_Frequency\_Request’ shall be set to zero. | C | 50 ms | LDW safety functionality | Deactivate functionality (reset frequency to 0) |
| Technical  Safety  Requirement  04 | The validity and integrity of data transmission for ‘LDW\_Frequency\_Request’ signal shall be ensured | C | 50 ms | Data transmission integrity check | Deactivate functionality (reset frequency to 0) |
| Technical  Safety  Requirement  05 | Memory test shall be conducted at startup of the EPS ECU to check for any faults in memory | A | Ignition cycle | SAFETY STARTUP | Max\_Torque\_Frequency is correct & Deactivate functionality will reset Frequency to 0 |

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

|  |  |  |
| --- | --- | --- |
| **ID** | **Validation Acceptance Criteria and Method** | **Verification Acceptance Criteria and Method** |
| Technical  Safety  Requirement  01 | Validate the Max\_Torque\_Amplitude is the chosen from the Lane Departure Warning Validation | Verify the Lane Departure Warning functionality is turned off. |
| Technical  Safety  Requirement  02 | Validate the ‘TORQUE\_LIMITER’ sends the error\_status\_torque\_limiter signal to the LDW\_SAFETY\_ACTIVATION. | Verify the Car Display ECU displays the Lane Departure Warning malfunction warning signal. |
| Technical Safety Requirement  03 | Validate the ‘TORQUE\_LIMITER’ sends ‘LDW\_Torque\_Request’ with zero. | Verify the Final EPS Torque generator receives a LDW\_Torque\_Request of zero. |
| Technical Safety Requirement 04 | Validate the ‘TORQUE\_LIMITER’ calculate and sends the correct cyclic redundancy check (CRC) and Alive counter for data transmission validity and integrity. | Verify the functionality is turn off if there is a CRC or Alive counter discrepancy. |
| Technical Safety Requirement  05 | Validate the Safety Startup Memory test to check memory faults catch memory faults. | Verify the Lane Departure Warning is turned off when the Safety Startup Memory fails. |

**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 Lane Keeping Assistance safety component shall ensure the lane keeping assistance torque is applied for less than Max\_Duration | C | 50 ms | LKA Safety | Lane Keeping Assistance torque to zero. |
| Technical  Safety  Requirement  02 | When the Lane Keeping Assistance function deactivates, the ‘LKA Safety’ shall send a signal to the Car Display ECU to turn on a warning light. | C | 50 ms | LKA Safety | Lane Keeping Assistance torque to zero. |
| Technical  Safety  Requirement  03 | When a failure is detected, the Lane Keeping Assistance function shall deactivate and the ‘LKA\_Torque\_Request’ shall be zero. | C | 50 ms | LKA Safety | Lane Keeping Assistance torque to zero. |
| Technical  Safety  Requirement  04 | The validity and integrity of the data transmission for ‘LKA\_Torque\_Request’ signal shall be ensured. | C | 50 ms | Data transmission integrity check | Lane Keeping Assistance torque to zero. |
| Technical  Safety  Requirement  05 | Memory test shall be conducted at startup of the EPS ECU to check for any memory problems | A | Ignition cycle | SAFETY STARTUP | Lane Departure Warning torque to zero. |

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

|  |  |  |
| --- | --- | --- |
| **ID** | **Validation Acceptance Criteria and Method** | **Verification Acceptance Criteria and Method** |
| Technical  Safety  Requirement  01 | Validate the Max\_Duration is set to the chosen value from LKA Validation Assistance Criteria | Verify the functionality is turned off after it is applied for Max\_Duration. |
| Technical  Safety  Requirement  02 | Validate the ‘TORQUE\_LIMITER’ sends the error\_status\_torque\_limiter signal to the LKA\_SAFETY\_ACTIVATION. | Verify the Car Display ECU displays the Lane Keeping Assistance malfunction warning signal. |
| Technical Safety Requirement  03 | Validate the ‘TORQUE\_LIMITER’ sends ‘LKA\_Torque\_Request’ with zero. | Verify the Final EPS Torque generator receives a LKA\_Torque\_Request of zero. |
| Technical Safety Requirement 04 | Validate the ‘TORQUE\_LIMITER’ calculate and sends the correct cyclic redundancy check (CRC) and Alive counter for data transmission validity and integrity. | Verify the functionality is turn off if there is a CRC or Alive counter discrepancy. |
| Technical Safety Requirement  05 | Validate the Safety Startup Memory test to check memory faults catch memory faults. | Verify the Lane Keeping Assistance is turned off when the Safety Startup Memory fails. |

## Refinement of the System Architecture

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## Allocation of Technical Safety Requirements to Architecture Elements

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| --- | --- | --- | --- | --- |
| **ID** | **Technical Safety Requirement** | **Electronic Power Steering ECU** | **Camera ECU** | **Car Display ECU** |
| Technical  Safety  Requirement  01-01-01 | The Lane Departure Warning 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.’ | **X** |  |  |
| Technical  Safety  Requirement  01-01-02 | When the Lane Departure Warning is deactivated, the ‘LDW Safety’ software module shall send a signal to the Car Display ECU to turn on a warning signal. | **X** |  |  |
| Technical  Safety  Requirement  01-01-03 | When a failure is detected by the Lane Departure Warning functionality, it shall deactivate the Lane Departure Warning feature and set ‘LDW\_Torque\_Request’ to zero. | **X** |  |  |
| Technical  Safety  Requirement  01-01-04 | The validity and integrity of the data transmission for ‘LDW\_Torque\_Request’ signal shall be ensured. | **X** |  |  |
| Technical  Safety  Requirement  01-01-05 | Memory test shall be conducted at startup of the EPS ECU to check for any memory problems | **X** |  |  |
| Technical  Safety  Requirement  01-02-01 | The Lane Departure Warning safety component shall ensure the frequency of the ‘LDW\_Torque\_Request’ sent to the ‘Final electronic power steering Torque’ component is below ‘Max\_Torque\_Frequency.’ | **X** |  |  |
| Technical  Safety  Requirement  02-01-01 | The Lane Keeping Assistance safety component shall ensure the duration of the lane keeping assistance torque is applied for less than Max\_Duration | **X** |  |  |
| Technical  Safety  Requirement  02-01-02 | When the Lane Keeping Assistance function deactivates, the ‘LKA Safety’ shall send a signal to the Car Display ECU to turn on a warning light. | **X** |  |  |
| Technical  Safety  Requirement  02-01-03 | When a failure is detected, the Lane Keeping Assistance function shall deactivate and the ‘LKA\_Torque\_Request’ shall be zero. | **X** |  |  |
| Technical  Safety  Requirement  02-01-04 | The validity and integrity of the data transmission for ‘LKA\_Torque\_Request’ signal shall be ensured. | **X** |  |  |
| Technical  Safety  Requirement  02-01-05 | Memory test shall be conducted at startup of the EPS ECU to check for any memory problems |  |  |  |

## Warning and Degradation Concept

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| WDC-01 | Turn off Lane Departure Warning functionality | Malfunction\_01,  Malfunction\_02 | Yes | Lane Departure Warning Malfunction Warning on Car Display |
| WDC-02 | Turn off Lane Keeping Assistance functionality | Malfunction\_03 | Yes | Lane Keeping Assistance Malfunction Warning on Car Display |