

Technical Safety Concept Lane Assistance

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# Document history

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# Purpose of the Technical Safety Concept

In this document, technical safety requirements are defined and assigned to the system architecture. These 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 | 50ms (Diagnostic Test Interval + Fault Reaction Time + Time in Safe State) | LDW torque request amplitude is set to zero |
| 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 | 50ms (Diagnostic Test Interval + Fault Reaction Time + Time in Safe State) | LDW torque request frequency is set to zero |
| Functional  Safety  Requirement  02-01 | The lane keeping item shall ensure that the lane keeping assistance torque is applied for only Max\_Duration | B | 500 ms | Switch Off Lane Assistance System |

## 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  01-01-01 | 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’. | C | 50 ms | LDW Safety | LDW torque request amplitude is set to zero |
| 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 | C | 50 ms | LDW Safety | LDW torque request amplitude is set to zero |
| 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. | C | 50 ms | LDW Safety | LDW torque request amplitude is set to zero |
| Technical  Safety  Requirement  01-01-04 | The validity and integrity of the data transmission for ‘LDW\_Torque\_Request’ signal shall be ensured. | C | 50 ms | Data Transmission Integrity Check | LDW torque request amplitude is set to zero |
| Technical  Safety  Requirement  01-01-05 | Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory | A | Ignition cycle | SAFETY STARTUP | LDW torque request amplitude is set 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  01-02-01 | The Lane Departure Warning safety component shall ensure that the amplitude of the ‘LDW\_Frequency\_Request’ sent to the ‘Final electronic power steering Torque’ component is below ‘Max\_Torque\_Frequency’. | C | 50 ms | LDW Safety | LDW torque request frequency is set to zero |
| Technical  Safety  Requirement  01-02-02 | 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 | LDW torque request frequency is set to zero |
| Technical  Safety  Requirement  01-02-03 | When a failure is detected by the Lane Departure Warning functionality, it shall deactivate the Lane Departure Warning feature and set ‘LDW\_Frequency\_Request’ to zero. | C | 50 ms | LDW Safety | LDW torque request frequency is set to zero |
| Technical  Safety  Requirement  01-02-04 | The validity and integrity of the data transmission for ‘LDW\_Frequency\_Request’ signal shall be ensured. | C | 50 ms | Data Transmission Integrity Check | LDW torque request frequency is set to zero |
| Technical  Safety  Requirement  01-02-05 | Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory | A | Ignition cycle | SAFETY STARTUP | LDW torque request frequency is set to zero |

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

|  |  |  |
| --- | --- | --- |
| **ID** | **Validation Acceptance Criteria and Method** | **Verification Acceptance Criteria and Method** |
| Technical  Safety  Requirement  01-01-01 | Validate the Max\_Torque\_Amplitude is the chosen from the Lane Departure Warning Validation | Verify the LDW request torque is set to zero |
| Technical  Safety  Requirement  01-01-02 | 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  01-01-03 | 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 01-01-04 | 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  01-01-05 | 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. |
| Technical Safety Requirement 01-02-01 | Validate the Max\_Torque\_Frequency set is the chosen from the Lane Departure Warning Acceptance Criteria. | Verify the functionality is turned off if the ‘LDW\_Torque\_Request’ frequency exceeds Max\_Torque\_Request. |

**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 LKA safety component shall ensure that the Duration of the 'LKA\_Duration\_Request' sent to the 'Final electronic power steering Torque' component is below Max\_Duration | C | 50ms | Lane Assistance Safety Functionality | LKA torque request amplitude and frequency is set to zero |
| Technical  Safety  Requirement  02 | As soon as the LKA function deactivates the LKA feature, the 'LKA Safety' software block shall send a signal to the car display ECU to turn on a warning light | C | 50ms | LKA Safety Functionality | LKA torque request amplitude and frequency is set to zero |
| Technical  Safety  Requirement  03 | As soon as a failure is detected by the LKA function, it shall deactivate the LKA feature and the 'LKA\_Duration\_Request' shall be set to zero | C | 50ms | LKA Safety Functionality | LKA torque request amplitude and frequency is set to zero |
| Technical  Safety  Requirement  04 | The validity and integrity of the data transmission for 'LKA\_Duration\_Request' signal shall be ensured | C | 50ms | Data Transmission Integrity Check | LKA torque request amplitude and frequency is set to zero |
| Technical  Safety  Requirement  05 | Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory | A | ignition cycle | SAFETY STARTUP | LKA torque request amplitude and frequency is set 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  01-01-01 | Validate the Max\_Torque\_Amplitude is the chosen from the Lane Departure Warning Validation | Verify the LDW request torque is set to zero. |
| Technical  Safety  Requirement  01-01-02 | 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  01-01-03 | 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 01-01-04 | 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  01-01-05 | 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. |
| Technical Safety Requirement 01-02-01 | Validate the Max\_Torque\_Frequency set is the chosen from the Lane Departure Warning Acceptance Criteria. | Verify the functionality is turned off if the ‘LDW\_Torque\_Request’ frequency exceeds Max\_Torque\_Request. |

## Refinement of the System Architecture



## Allocation of Technical Safety Requirements to Architecture Elements

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 start up 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\_Reques’ 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 start up of the EPS ECU to check for any memory problems |  |  |  |

## Warning and Degradation Concept

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Degradation Mode** | **Trigger for Degradation Mode** | **Safe State invoked?** | **Driver Warning** |
| WDC-01 | Turn off Lane Departure Warning functionality | Malfunction\_01,  Malfunction\_02,  Malfunction\_04 | Yes | Lane Departure Warning Malfunction Warning on Car Display |
| WDC-02 | Turn off Lane Keeping Assistance functionality | Malfunction\_03,  Malfunction\_05 | Yes | Lane Keeping Assistance Malfunction Warning on Car Display |