

Technical Safety Concept Lane Assistance

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# Document history

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# Purpose of the Technical Safety Concept

In this document, new requirements are defined and assigned 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

**[Instructions: Provide the functional safety requirements derived in the functional safety concept ]**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **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 01-03 | Indicator of a ready LDW system should be added, LDW\_Status, on Car Display system or other place for driver to notice | QM | 10 ms | Other indicator should be added |
| 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. |
| Functional Safety Requirement 02-02 | The Lane Keeping assistance shall be deactivated when the electronic power steering ECU detects the camera sensor is not working. | C | 10 ms | Function is deactivated. |

## Refined System Architecture from Functional Safety Concept

**[Instructions: Provide the refined system architecture from the functional safety concept]**



### 

### Functional overview of architecture elements

**[Instructions: Provide a description for each functional safety element; what is each element's purpose in the lane assistance item? ]**

|  |  |
| --- | --- |
| **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

**[Instructions: Fill in the technical safety requirements for the lane departure warning first functional safety requirement. We have provided the associated functional safety requirement in the first table below. Hint: The technical safety requirements were discussed in the lesson videos. The architecture allocation column should contain element names such as LDW Safety block, Data Transmission Integrity Check, etc. Allocating the technical safety requirements to the "EPS ECU" does not provide enough detail for a technical safety concept.]**

**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 | Lane Departure Warning torque 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 | Lane Departure Warning torque 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 | Lane Departure Warning torque 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 | LDW Safety | Lane Departure Warning torque to zero. |
| Technical  Safety  Requirement  01-01-05 | Memory test shall be conducted at start up of the EPS ECU to check for any memory problems | A | Ignition cycle | Data Transmission Integrity Check | Lane Departure Warning torque to zero. |

**[Instructions: Fill in the technical safety requirements for the lane departure warning second functional safety requirement. We have provided the associated functional safety requirement in the table below. Hint:. Most of the technical safety requirements will be the same. At least one technical safety requirement will have to be slightly modified because we are talking about frequency instead of amplitude. These requirements were not given in the lessons]**

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 the frequency of the ‘LDW\_Torque\_Reques’ sent to the ‘Final electronic power steering Torque’ component is below ‘Max\_Torque\_Frequency.’ | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |

Functional Safety Requirement 01-03 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  01-03 | Indicator of a ready LDW system should be added, LDW\_Status, on Car Display system or other place for driver to notice |  |  | X |

Technical Safety Requirements related to Functional Safety Requirement 01-03 are:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **ID** | **Technical Safety Requirement** | **ASIL** | **Fault Tolerant Time Interval** | **Architecture Allocation** | **Safe State** |
| Technical  Safety  Requirement  01-03-01 | The Car Display component shall ensure the indicator LDW\_Status on green when the LDW system is ready to use | QM | 50 ms | LDW Safety | Lane Departure Warning indicator turns to green. |

**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  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 | C | 500 ms | LKA Safety | Lane Keeping Assistance torque to zero. |
| 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. | C | 500 ms | LKA Safety | Lane Keeping Assistance torque to zero. |
| 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. | C | 500 ms | LKA Safety | Lane Keeping Assistance torque to zero. |
| Technical  Safety  Requirement  02-01-04 | The validity and integrity of the data transmission for ‘LKA\_Torque\_Request’ signal shall be ensured. | C | 500 ms | LKA Safety | Lane Keeping Assistance torque to zero. |
| Technical  Safety  Requirement  02-01-05 | Memory test shall be conducted at start up of the EPS ECU to check for any memory problems | A | Ignition cycle | Data Transmission Integrity Check | 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  02-01-01 | 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  02-01-02 | 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  02-01-03 | 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 02-01-04 | 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  02-01-05 | 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

## 

## 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  01-03-01 | The Car Display component shall ensure the indicator LDW\_Status on green when the LDW system is ready to use |  |  | **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 Malfunction\_05 | 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 |