

Functional Safety Concept Lane Assistance

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# Document history

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# Table of Contents

[Document history](#_1t3h5sf)

[Table of Contents](#_ktt3lgighckp)

[Purpose of the Functional Safety Concept](#_fulgh8sf1ocg)

[Inputs to the Functional Safety Analysis](#_757cx6xm46zb)

[Safety goals from the Hazard Analysis and Risk Assessment](#_pi1c1upmo8jt)

[Preliminary Architecture](#_s0p6ihti6jgk)

[Description of architecture elements](#_cqb49updinx4)

[Functional Safety Concept](#_mx8us8onanqo)

[Functional Safety Analysis](#_mtn6qbhgsr36)

[Functional Safety Requirements](#_frlc9y84ede8)

[Refinement of the System Architecture](#_74udkdvf7nod)

[Allocation of Functional Safety Requirements to Architecture Elements](#_g2lqf7kmbspk)

[Warning and Degradation Concept](#_4w6r8buy4lrp)

# Purpose of the Functional Safety Concept

Look at the item from a higher level, identify the new requirements and allocate these requirements to system diagrams

# Inputs to the Functional Safety Concept

## Safety goals from the Hazard Analysis and Risk Assessment

|  |  |
| --- | --- |
| **ID** | **Safety Goal** |
| Safety\_Goal\_01 | 1. The oscillating steering torque from the lane departure warning function shall be limited |
| Safety\_Goal\_02 | 1. The lane keeping assistance function shall be time limited, and the additional steering torque shall end after a given time interval so that the driver cannot misuse the system for autonomous driving. |

## Preliminary Architecture



### Description of architecture elements

|  |  |
| --- | --- |
| **Element** | **Description** |
| Camera Sensor | Captures the road image stream video |
| Camera Sensor ECU | the camera system detects lane and lane departure |
| Car Display | Displays warning and information to the driver |
| Car Display ECU | Receive commands from other sub systems what and when to be displayed and drives the display according to these commands |
| Driver Steering Torque Sensor | Senses the torque applied to the steering wheel |
| Electronic Power Steering ECU | Turns and vibrates the steering wheel according to the request received from Camera Sensor ECU |
| Motor | Applies torque to the steering wheel according to the value it received from the Camera Sensor ECU |

# 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 |
| 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 amplitude (above limit |
| 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 lane keeping item shall ensure that the lane departure oscillation torque amplitude is below Max\_Torque\_Amplitude | C | 50ms | The oscillation torque amplitude is below Max\_Torque\_Amplitude |
| Functional  Safety  Requirement  01-02 | The lane keeping item shall ensure that the lane departure oscillation torque frequency is below Max\_Torque\_Frequency | C | 50ms | The oscillation torque frequency is below Max\_Torque\_ Frequency |

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 | max torque amplitude, we chose a reasonable value(low enough to alert the driver and not to cause of steering wheel) | When the torque amplitude crosses the limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval. |
| Functional  Safety  Requirement  01-02 | max torque frequency, we chose a reasonable value(low enough to alert the driver and not to cause of steering wheel) | When the torque frequency crosses the limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval. |

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 | 500ms | Lane Keeping Assistance torque set to zero |

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 | max\_duration chosen really did dissuade drivers from taking their hands off the wheel | the system really does turn off if the lane keeping assistance every exceeded max\_duration |

## Refinement of the System Architecture



## 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 lane keeping item shall ensure that the lane departure oscillation torque amplitude is below Max\_Torque\_Amplitude | **X** |  |  |
| Functional  Safety  Requirement  01-02 | The lane keeping item shall ensure that the lane departure oscillation torque frequency is below Max\_Torque\_Frequency | **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 | Turning the system off (The torque request from the lane keeping assistance will be set to zero) | Malfunction\_01  Malfunction\_02 | YES | Turn on Lane Departure warning system malfunction warning light |
| WDC-02 | Turning the system off (The torque request from the lane keeping assistance will be set to zero) | Malfunction\_03 | YES | Turn on Lane Keep Assis system malfunction warning light |