

Functional Safety Concept Lane Assistance

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# Document history

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| 03.06.2018 | 1.1 | Ankith Manjunath | Functional safety concept first version |
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# Purpose of the Functional Safety Concept

**The main higher view of functional safety concept for a system under test is to make the system functionally safe. Functionally safe system has to reduce the impact of occuring hazardous situations.**

# Inputs to the Functional Safety Concept

## Safety goals from the Hazard Analysis and Risk Assessment

|  |  |
| --- | --- |
| **ID** | **Safety Goal** |
| Safety\_Goal\_01 | The lane departure warning subsystem shall apply an oscillating torque less than the limit |
| Safety\_Goal\_02 | The lane keeping assistance shall be time limited and shall apply steering torque for a limited period of time |

## Preliminary Architecture

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### Description of architecture elements

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|  |  |
| --- | --- |
| **Element** | **Description** |
| Camera Sensor | Provide video feed of the road in front of the vehicle |
| Camera Sensor ECU | Detect lane markings from the video feed. Detect the position of the vehicle from the center of the lane. |
| Car Display | Display to the driver if functionality is on/off. Display the driver for a gradual degradation |
| Car Display ECU | Receive data about function on/off and also for function gradual degradation |
| Driver Steering Torque Sensor | Sense the steering wheel torque from the driver |
| Electronic Power Steering ECU | Determine the amount of steering torque needed for the functionality and normal operation mode |
| Motor | Provide the required torque from the software torque input |

# 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 | Vehicle out of control |
| Malfunction\_02 | Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback | LESS | Collision with another vehicle |
| Malfunction\_03 | Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane | NO | Collision with another vehicle |

## 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 torque amplitude by lane departure warning system is below MAX\_TORQUE\_AMPLITUDE | C | 50ms | The lane keeping item is turned off and driver is notified |
| Functional  Safety  Requirement  01-02 | The lane keeping item shall ensure that the torque frequency by the lane departure warning is below MAX\_TORQUE\_FREQUENCY | C | 50ms | The lane keeping item is turned off and driver is notified |

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 | Choose a suitable value for MAX\_TORQUE\_AMPLITUDE | Verify the FTTI and safe state degradation using the validated MAX\_TORQUE\_AMPLITUDE |
| Functional  Safety  Requirement  01-02 | Choose a suitable value for MAX\_TORQUE\_FREQUENCY | Verify the FTTI and safe state degradation using the validated MAX\_TORQUE\_FREQUENCY |

Lane Keeping Assistance (LKA) Requirements:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Functional Safety Requirement** | **ASIL** | **Fault Tolerant Time Interval** | **Safe State** |
| Functional  Safety  Requirement  02-01 | The lane keeping item shall ensure that the steering torque TIME\_FOR\_TORQUE is applied for a limited period of time . | B | 500ms | The lane keeping item is turned off and driver is notified |

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 | Validate the TIME\_FOR\_TORQUE such that the system is not misinterpreted as an autonomous function | The FTTI and safe state is verfied using the validated TIME\_FOR\_TORQUE |

## Refinement of the System Architecture

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## 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 torque amplitude by lane departure warning system is below MAX\_TORQUE\_AMPLITUDE | **x** | **-** | **-** |
| Functional  Safety  Requirement  01-02 | The lane keeping item shall ensure that the torque frequency by the lane departure warning is below MAX\_TORQUE\_FREQUENCY | **x** | **-** | **-** |
| Functional  Safety  Requirement  02-01 | The lane keeping item shall ensure that the steering torque TIME\_FOR\_TORQUE is applied for a limited period of time . | **x** | **-** | **-** |

## Warning and Degradation Concept

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Degradation Mode** | **Trigger for Degradation Mode** | **Safe State invoked?** | **Driver Warning** |
| WDC-01 | Turn off functionality | Malfunction\_01  Malfunction\_02 | Yes | LDW warning on the screen |
| WDC-02 | Turn off functionality | Malfunction\_03 | Yes | LKA warning on the screen, Driver to take over the car |