

Functional Safety Concept Lane Assistance

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# Document history

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| 20 June, 2018 | 1.0 | Akhil Suri | Initial Draft |
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# Purpose of the Functional Safety Concept

The Functional Safety Concept documents the identified system high level requirements. These requirements are allocated to different parts of the item architecture. Technical safety requirements will be derived from the safety concepts. The validation and verification concepts for these requirements are presented as well.

# Inputs to the Functional Safety Concept

## Safety goals from the Hazard Analysis and Risk Assessment

|  |  |
| --- | --- |
| **ID** | **Safety Goal** |
| Safety\_Goal\_01 | The oscillating steering torque from the lane departure warning function shall be limited. |
| Safety\_Goal\_02 | The Lane Keeping Assistance 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 | To provide the images captured from camera to the camera Sensor ECU |
| Camera Sensor ECU | Images will be analyzed and will calculate the car position and detect the lane lines. |
| Car Display | Display the status of the systems and warnings when a system malfunction |
| Car Display ECU | It will show the lane departure and lane keeping assistance warning status, by controlling the car display component. |
| Driver Steering Torque Sensor | It measures the torque applied to the steering wheel. |
| Electronic Power Steering ECU | Measure the torque applied to the steering wheel by the driver. |
| Motor | The component is responsible for applying the work required to produce the torque required to execute actions delivered to the power steering 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 frequency (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 oscillating torque amplitude is below Max\_Torque\_Amplitude | C | 50ms | Set Lane Departure Warning Torque Request Amplitude to zero |
| Functional  Safety  Requirement  01-02 | The lane departure oscillating torque  frequency is below  Max\_Torque\_Frequency | C | 50ms | Set vibration torque frequency to zero |

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 | Value of Max\_Torque\_Amplitude is chosen such that it is adequate enough to warn the driver and low enough to not cause steering loss. | Validate whether the system turns off when Max\_Torque\_Amplitude is exceeded. |
| Functional  Safety  Requirement  01-02 | Value of Max\_Torque\_Frequency is chosen such that it is adequate enough to warn the driver and low enough to not cause steering loss. | Validate whether the system turns off when Max\_Torque\_Frequency is exceeded. |

Lane Keeping Assistance (LKA) Requirements:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Functional Safety Requirement** | **ASIL** | **Fault Tolerant Time Interval** | **Safe State** |
| Functional  Safety  Requirement  02-01 | Lane keeping assistance function shall be time limited and the additional steering torque shall end after a given timer interval so that the driver cannot misuse the system for autonomous driving | B | 500ms | Set lane keeping assistance torque to be 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 | The 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 electronic power steering ECU should be ensuring that the lane departure oscillating torque frequency is below Max\_Torque\_Frequency | **Responsible** | **Not Responsible** | **Not Responsible** |
| Functional  Safety  Requirement  01-02 | The Electronic Power Steering ECU shall ensure that the amplitude of Lane Departure Warning oscillating torque is below Max\_Torque\_Amplitude | **Responsible** | **Not Responsible** | **Not Responsible** |
| Functional  Safety  Requirement  02-01 | The Electronic Power Steering Shall ensure that the Lane Keeping Torque is applied for a maximum duration of Max\_Duration | **Responsible** | **Not Responsible** | **Not Responsible** |

## Warning and Degradation Concept

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Degradation Mode** | **Trigger for Degradation Mode** | **Safe State invoked?** | **Driver Warning** |
| WDC-01 | Turn OFF the Functionality | Malfunction\_01 Malfunction\_02 | Yes | A warning light on the dashboard. |
| WDC-02 | Turn OFF the Functionality | Malfunction\_03 | Yes | A warning light on the dashboard. |