**Function Specification for Emergency Brake Assist**

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History

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|  |  |  |  |

Glossary

|  |  |
| --- | --- |
|  | Description |
| EBA | Emergency Braking Assist |
| FCW | Forward Collision Warning |
| ISO | International Organization for Standardization |
| HBA | Hydraulic Brake Assist |
| CCRs | Car to Car Stationary |
| CCRb | Car to Car braking |
| CCRm | Car to Car moving |
|  |  |

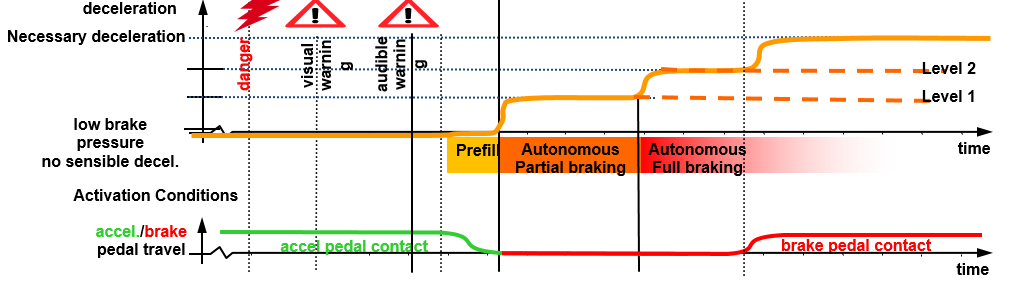
# Function Description

## 1.1 Function Introduction

The EBA system is meant to avoid accidents by means of driver visual/audible/haptic alert, automatic partial and full braking. The function could be realized by a forward-looking sensor system (e.g. radar, camera), detecting and evaluating the distance and speed of the following vehicle or crossing pedestrians and commanding a deceleration by the brake system if required.

## 1.2 Functional Principle

The EBA intervention is cascaded, which means that the deceleration will be increased during the EBA intervention. In an early phase, the function can activate a Collision Warning. In addition, EBA can request Prefill, change the brake assist thresholds and initiate an automatic brake request, see figure 1. To increase reliability, the assumed driver’s intention is taken into account. This is mainly done by assessing the steering and acceleration activities. EBA shall be deactivated during reverse driving.



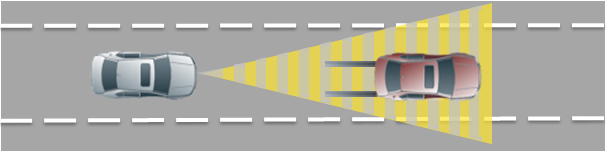
## 1.3 Distance warning

The Distance warning is used to inform the driver the distance between the ahead vehicle and host vehicle too small. Distance warning (Latent warning) has no relation with FCW, its independent of FCW. Distance warning is only used for moving vehicle from 65kph – 180kph. Distance warning is not available for pedestrian.

Latent warning function application scene and effective operating range are given below:

1. Distance Warning is activated when the Ego vehicle is approaching a moving vehicle

With a speed which is in the range of 65kph-180kph



2. Time gap to the vehicle ahead, ie

TTC <=1.2s for Driver setting as EARLY

TTC <=0.9s for Driver setting as MIDDLE

TTC <=0.7s for Driver setting as LATE

The TTC values can be tuned as per the customer needs

The definitions of Driver settings are defined in the section 4

Latent warning shall be deactivated under the following conditions:

1) When the Ego vehicle speed is below 65kph (Ego vehicle speed < 65kph)

2) When the driver switches off the ‘Warning ’ through HMI

## 1.4 Forward Collision warning

The Forward Collision Warning shall be generated when there is a high risk of a collision but not too early making the driver irritated about the warning. The warning should give the driver the possibility to react and de-escalate the situation.

This warning is performed by visual and acoustic indications.

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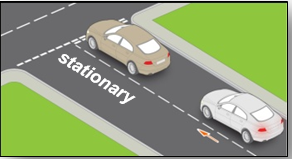
The activation speed range of FCW shall be active is 7kph to 180kph in forward direction under car-to-car scenarios and 7kph to 85kph in forward direction under car-to-pedestrian /car-to -cyclist scenarios.

### 1.4.1 Forward Collision warning on Vehicle

FCW function application scene and effective operating speed range are given below:

* **Stationary Vehicle**

a) The operating speed range of FCW for a stationary vehicle is 7kph to 85kph.



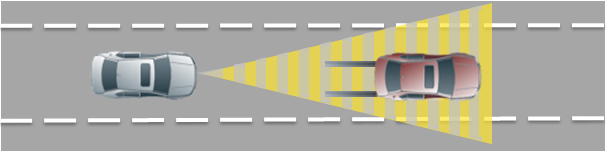
b) FCW for shall be triggered under the following TTC values as per the EUNCAP tests

|  |  |
| --- | --- |
| CCRs |  |
| Speed(kph) | TTC(seconds) |
| 30 | TTC >=1.17 |
| 40 | TTC >=1.35 |
| 50 | TTC >=1.53 |
| 60 | TTC >=1.67 |
| 70 | TTC >=1.82 |
| 80 | TTC >=1.91 |

**Note: The TTC values are as per the Driver Sensitivity setting as MIDDLE**

* **Moving Vehicle**

1. The operating speed range of FCW for a moving vehicle is 7kph to 180kph



1. FCW for shall be triggered under the following TTC values as per the EUNCAP tests

|  |  |
| --- | --- |
| CCRm |  |
| Speed(km/h) | TTC(seconds) |
| 50 | 1.17 |
| 60 | 1.35 |
| 70 | 1.53 |
| 80 | 1.7 |
| >80 | >1.7 |

**Note: The TTC values are as per the Driver Sensitivity setting as MIDDLE**

### 1.4.2 Forward Collision warning on VRU’s

Pedestrian and Bicycle are referred as VRU’s (Vulnerable Road Users)

As per the EuNCAP test scenarios, the FCW is activated where a pedestrian is moving in direction of the ego vehicle path and also on the pedestrian who is standing in the direction of the ego vehicle path.

FCW on Pedestrian is activated when the following conditions are fulfilled:

1. Time to collision (TTC) <= 1.9 seconds
2. Ego vehicle velocity should be in the range 7kph-85kph
3. Walking Pedestrians at a speed up to 5kph
4. Lateral distance criteria is fulfilled: 1.5m to -1.5m considering 25% hit point

FCW on Cyclist is activated when the following conditions are fulfilled:

1. Ego vehicle velocity should be in the range 7kph-85kph
2. Time to collision (TTC) < 1.9 seconds

### 1.4.3 FCW Deactivation

FCW on Vehicle and VRU shall be suppressed under the following conditions:

1. Driver activity is high enough , which means

* Steering angle is greater than 120 degrees
* Steering angle gradient is greater than 40deg/s for the Ego speed > 15m/s or

Steering angle gradient is greater than 200deg/s for the speed Ego speed < 5m/s

For the speeds between 5m/s-15m/s the gradient value is calculated by interpolation

And corresponding condition should be satisfied (ie Steering angle grad > interpolated value)

1. Driver overtake request when one of the conditions is fulfilled.

* Accelerator pedal or Gas pedal position > 90%
* Accelerator Pedal position gradient > 250 % /s

1. Driver is braking redundantly when one of the following condition is fulfilled

* Brake Pedal is active
* Brake pressure is above the threshold: 3 bar

1. Driver switches off the ‘FCW Warning’ through HMI
2. Under Exceptional operational situation

* Engine OFF/Ignition OFF
* Gear is either N(Neutral)/R(Reverse)
* Yaw rate signal quality is NOT OK/faulty
* Vehicle velocity signal quality is NOT OK/faulty
* ESP has an error
* Steering wheel angle signal quality is NOT OK/faulty
* Gas pedal position signal quality is NOT OK/faulty

## 1.5 Prefill

If the probability of a collision reaches a certain level, EBA requests a Prefill. When requesting Prefill, a pressure is applied to the brake system, which does not lead to noticeable deceleration. A Prefill leads to reduced response times of driver’s brake apply and increased deceleration response of the vehicle by removing the mechanical clearances between brake pad and brake disc.

When requesting Prefill, a pressure is applied to the brake system, which does not lead to noticeable deceleration. Deceleration is fixed to 0.4m/s-2 on prefill request

The working speed range of Prefill function shall be the same as that of Prebrake function.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Prefill | Speed | Vehicle | | Pedestrians | Cyclist |
| Moving | Stationary |
| Min(kph) | 7 | 7 | 7 | 7 |
| Max(kph) | 180 | 85 | 85 | 85 |

### 1.5.1 Prefill Deactivation Conditions

Prefill function is suppressed under the following conditions:

1. Driver activity is high enough , which means

* Steering angle is greater than 120 degrees
* Steering angle gradient is greater than 40deg/s for the Ego speed > 15m/s or

Steering angle gradient is greater than 200deg/s for the speed Ego speed < 5m/s

For the speeds between 5m/s-15m/s the gradient value is calculated by interpolation

And corresponding condition should be satisfied (ie Steering angle grad > interpolated value)

1. Driver overtake request when one of the conditions is fulfilled.

* Accelerator pedal or Gas pedal position > 90%
* Accelerator Pedal position gradient > 250 %/s

1. Driver is braking redundantly when one of the following condition is fulfilled

* Brake Pedal is active
* Brake pressure is above the threshold: 3 bar

1. Driver switches off the ‘AEB switch’ through HMI
2. Under Exceptional operational situation

* Engine OFF/Ignition OFF
* Gear is either N(Neutral)/R(Reverse)
* Yaw rate signal quality is NOT OK/faulty
* Vehicle velocity signal quality is NOT OK/faulty
* ESP has an error
* Steering wheel angle signal quality is NOT OK/faulty
* Gas pedal position signal quality is NOT OK/faulty

## 1.6 Warning Jerk

If required, radar will send a brake jerk request flag to the brake system to execute a brake jerk as haptic warning for EBA system. The warning jerk functionality uses a short brake pressure pulse to decelerate the vehicle significant to the driver. The intention is to make sure to draw the driver’s full attention to the traffic situation in front of the vehicle. In addition to the waning jerk request flag, the EBA system will also send sensitivity level to ESC according to current to emergency situation.

The brake jerk must be implemented in a manner that ensure the driver will remain in control of the vehicle.

### 1.6.1 Warning Jerk activation conditions:

1. The operating speed ranges for warning jerk is same as defined for FCW for stationary

And moving targets

1. Warning Jerk have 3 levels:

|  |  |  |
| --- | --- | --- |
| Warning Jerk Level | Condition | Deceleration Request |
| 1 | Required Longitudinal negative acceleration is in the range (-2m/s-2 to -4m/s-2) | 0.2m/s-2 |
| 2 | Required Longitudinal negative acceleration is in the range (-4m/s-2 to -6m/s-2) | 0.3m/s-2 |
| 3 | Required Longitudinal negative acceleration is < -6m/s-2 | 0.4m/s-2 |

The levels are defined in such a way that the jerk shall be felt by the driver, but at the same time the driver shall not lose control of the vehicle/shall not feel uncomfortable while driving.

### 1.6.2 Warning Jerk de-activation conditions:

Warning Jerk will be suppressed or deactivated under the following conditions

1. Driver activity is high enough , which means

* Steering angle is greater than 120 degrees
* Steering angle gradient is greater than 40deg/s for the Ego speed > 15m/s or

Steering angle gradient is greater than 200deg/s for the speed Ego speed < 5m/s

For the speeds between 5m/s-15m/s the gradient value is calculated by interpolation

And corresponding condition should be satisfied (ie Steering angle grad > interpolated value)

1. Driver overtake request when one of the conditions is fulfilled.

* Accelerator pedal or Gas pedal position > 90%
* Accelerator Pedal position gradient > 250 %/s

1. Driver is braking redundantly when one of the following condition is fulfilled

* Brake Pedal is active
* Brake pressure is above the threshold: 3 bar

1. Driver switches off the ‘FCW Warning’ through HMI
2. Under Exceptional operational situation

* Engine OFF/Ignition OFF
* Gear is either N(Neutral)/R(Reverse)
* Yaw rate signal quality is NOT OK/faulty
* Vehicle velocity signal quality is NOT OK/faulty
* ESP has an error
* Steering wheel angle signal quality is NOT OK/faulty
* Gas pedal position signal quality is NOT OK/faulty

## 1.7 HBA(Hydraulic Brake Assist)

EBA can support the Brake Assist function, which is implemented in the brake system. Within EBA the threat assessment is used to modify the minimum triggering level of the HBA. Multiple Levels of reduction can be requested from the sensor.

The **H**ydraulic **B**rake **A**ssist (HBA) function supports the driver to reach the shortest possible stopping distance in panic braking situations, by building up the maximum necessary brake pressure. Driver’s reaction depends on his "training state" (instinctive knowledge: fast and full brake application). Normally, untrained drivers react far too hesitantly especially with respect to pedal force. However all driver types apply the brake pedal much faster compared to non-emergency situations. The HBA detects panic brake situations and can reduce the braking distance by an active pressure increase up to maximum wheel pressure limited by ABS. Figure 2 shows differences of the wheel brake pressures applied by a trained driver and a normal driver with or without HBA.



**T**hreshold **A**dapting (TA) is provided as different criticality levels which determine the magnitude of threshold adapting. The criticality level is dependent on the situation and the required collision avoidance deceleration.

### 1.7.1 HBA Activation Conditions

Brake assist shall be active when following conditions are valid

* Driver does not accelerate
* Driver braking is detected
* Ego Car is not driving backwards
* ESP system is active
* The minimum vehicle velocity for HBA activation is exceeded. The minimum velocities for stationary and moving targets are mentioned in the below table

HBA operating speed ranges

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| HBA | Speed(kph) | Vehicle | | Pedestrian |
| Moving | Stationary |
| Min(kph) | 25 | 25 | 25 |
| Max(kph) | 180 | 85 | 65 |

### 1.7.2 HBA Levels

HBA levels are defined based on the required negative acceleration

|  |  |
| --- | --- |
| **HBA Levels for vehicles** | **Condition** |
| 1 | This is the default level chosen if the required negative acceleration doesn’t meet the criteria for either Level 2 or 3. |
| 2 | Required negative acceleration >=6m/s2 |
| 3 | Required negative acceleration >=10m/s2 |

|  |  |
| --- | --- |
| **HBA Levels for Pedestrians** | **Condition** |
| 4 | This is the default level chosen if the required negative acceleration doesn’t meet the criteria for either Level 2 or 3. |
| 5 | Required negative acceleration >=6m/s2 |
| 6 | Required negative acceleration >=10m/s2 |

### 1.7.3 HBA Deactivation Conditions

The Hydraulic Brake Assist function shall be deactivated or suppressed under the following conditions:

1. Driver activity is high enough , which means

* Steering angle is greater than 120 degrees
* Steering angle gradient is greater than 40deg/s for the Ego speed > 15m/s or

Steering angle gradient is greater than 200deg/s for the speed Ego speed < 5m/s

For the speeds between 5m/s-15m/s the gradient value is calculated by interpolation

And corresponding condition should be satisfied (ie Steering angle grad > interpolated value)

1. Driver overtake request when one of the conditions is fulfilled.

* Accelerator pedal or Gas pedal position > 90%
* Accelerator Pedal position gradient > 250 %/s

1. Driver switches off the ‘AEB switch’ through HMI
2. Under Exceptional operational situation

* Engine OFF/Ignition OFF
* Gear is either N(Neutral)/R(Reverse)
* Yaw rate signal quality is NOT OK/faulty
* Vehicle velocity signal quality is NOT OK/faulty
* Steering wheel angle signal quality is NOT OK/faulty
* Gas pedal position signal quality is NOT OK/faulty
* Due to Radar Misalignment
* Radar Blockage

1. Driver releases the Brake completely
2. ESP system reported as inactive/faulty
3. Criticality of the situation dissolves(preceding target vehicle does not exist any longer)

## ****1.8 Autonomous Emergency brake (AEB)****

After the audible and visual alerts, if the driver does not react during the warning event, the automatic braking is intended to reduce the overall vehicle velocity or mitigating the forces within the collision.

* In critical situations AEB might request deceleration without any driver interaction. If a certain probability of a collision with preceding vehicle or pedestrian has been predicted by considering different input parameters like relative vehicle speed and situation hypothesis, the brakes will be actuated.
* Braking is performed until predicted motion of the vehicles shows no further closing movement (relative acceleration has to be considered too) or until the maximum intervention time (5s) is elapsed.
* The function sends out a deceleration request to the brake when necessary. The level of the deceleration request is derived from numerous information (e.g. the distance and the closing velocity to the target object and from the own velocity and acceleration).
* The function does not consider specific environmental conditions like actual friction of road (e.g. actual friction, etc.).

The operating Speed range for EBA to act on moving vehicle is 7 – 180kph.

The operating Speed range for EBA to act on stationary vehicle is 7-85kph

The operating Speed range for EBA to act on Pedestrian is between 7kph to 85kph

The operating Speed range for EBA to act on Cyclist is between 7kph to 85kph

**Note that EBA activation on stationary Pedestrian /Cyclist requires Camera confirmation**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AEB | Speed(kph) | Vehicle | | Pedestrian | Cyclist |
| Moving | Stationary |
| Min(kph) | 7 | 7 | 7 | 7 |
| Max(kph) | 180 | 85 | 85 | 85 |

### 1.8.1 Pre Brake Deceleration

EBA-CCR (EBA on Vehicle ) has two brake levels

• BrakeLevel1 (Partial Brake) – Deceleration is limited to 5m/s2

• BrakeLevel2 (Full Brake) – Deceleration is limited to 10m/s2

• Maximum speed reduction is limited to 50kph for a cascaded braking

EBA-PP(EBA on Pedestrian and Cyclist) has two brake levels

• BrakeLevel1 (Partial Brake – Deceleration is limited to 5m/s2

• BrakeLevel2 (Full Brake) – Deceleration is limited to 10m/s2

• Maximum speed reduction is limited to 40Kph for a cascaded braking

The brake levels are calculated based on various factors like

1. Situation interpretation
2. Longitudinal distance (Distance between Ego vehicle and the target object)
3. Relative velocity between Ego and the target vehicle
4. TTC(Time to collision), TTB(Time to brake)

### 1.8.2 EBA Deactivation Conditions

EBA shall be suppressed or deactivated under the following conditions:

1. Driver activity is high enough , which means

* Steering angle is greater than 120 degrees
* Steering angle gradient is greater than 40deg/s for the Ego speed > 15m/s or

Steering angle gradient is greater than 200deg/s for the speed Ego speed < 5m/s

For the speeds between 5m/s-15m/s the gradient value is calculated by interpolation

And corresponding condition should be satisfied (ie Steering angle grad > interpolated value)

1. Driver overtake request when one of the conditions is fulfilled.

* Accelerator pedal or Gas pedal position > 90%
* Accelerator Pedal position gradient > 250 %/s

1. Driver switches off the ‘AEB switch’ through HMI
2. Under Exceptional operational situation

* Engine OFF/Ignition OFF
* Gear is either N(Neutral)/R(Reverse)
* Yaw rate signal quality is NOT OK/faulty
* Vehicle velocity signal quality is NOT OK/faulty
* Steering wheel angle signal quality is NOT OK/faulty
* Gas pedal position signal quality is NOT OK/faulty
* Due to Radar Misalignment
* Radar Blockage

1. ESP system reported as inactive/faulty
2. Driver is braking very hard such that the required brake pressure is achieved

### 1.8.3 Vehicle Standstill Condition

After the brakes are applied and the Ego vehicle speed falls below 2kph, EBA shall send the

Brake request for another 1.5 sec to Brake ECU to hold the brakes, in order to avoid the roll

Over of the vehicle due to inertia and keep the vehicle in Standstill position

## 1.9 Interaction with Other Functions

### 1.9.1 FSRA(Full Speed Range ACC)

The function shall be inactive during EBA intervention. After EBA intervention the ACC function shall regulate ego vehicle speed again.

When AEB is active, then ACC monitors the AEB active message on the CAN bus and thus ACC goes to STAND BY mode

### 1.9.2 LDP

The Lane Departure Protection function shall be inactive during EBA intervention. After EBA intervention the

LDP function shall regulate ego vehicle again after activation by driver.

When AEB is active, then LDP monitors the AEB active message on the CAN bus and thus LDP is suppressed

# State Flow and Transition Conditions

## 2.1 EBA State Flow

IGNITION\_ON

(AND)

(AEB\_SWITCH || FCW\_SWITCH)==ON

(AND)

Signal quality for critical signals [(Refer section 2.1.1.2)==](#_Critical_Signals)OK

IGNITION\_OFF

(OR)

(AEB\_SWITCH || FCW\_SWITCH)==OFF

(OR)

Signal quality for critical signals ([Refer section 2.1.1.2)](#_Critical_Signals) == NOK

IGNITION\_OFF

(OR)

(AEB\_SWITCH || FCW\_SWITCH)==OFF

(OR)

Signal quality for critical signals ([Refer section 2.1.1.2](#_Critical_Signals)) ==NOK

Ego speed in range

(AND)

Driver monitor conditions == TRUE (Refer the transition STANDBY to ACTIVE regarding the driver monitor conditions)

(AND)

Current Gear == FWD Gear

(AND)

Signal quality for critical signals ([Refer section 2.1.1.2](#_Critical_Signals)) == OK

Ego speed not in range

(OR)

Driver monitor conditions == FALSE

(Refer the transition ACTIVE to STANDBY regarding the driver monitor conditions)

(OR)

Current Gear! =FWD Gear

### 2.1.1 EBA State Transition Conditions

|  |  |  |  |
| --- | --- | --- | --- |
| System State | Transition State | Transition Conditions | Affected CAN signals |
| (OFF) | (Standby) | Engine running /Ignition ON  (AND)  AEB Switch is ON for Emergency brake  Or FCW switch is ON for warning | EnASSStaHSCHSC2=0x1(Engine running)/ EnRunAHSCHSC2=0x1(Currently these are two signals related go Engine running state. Customer need to clarify which is the correct Signal to be used)  (AND)  AEBSwReqHSC2=0x02(ON)/  FCWSwReqHSC2= 0x2(ON) |
| (Standby) | (Active) | Ego speed is in the speed range for the respective modules (ie FCW,Prefill, Emergency brake etc)  (AND)  Current gear is one of the forward gears  (AND)  Other relevant parameters like TTC ,Driver monitoring conditions are met  Driver monitoring conditions are as follows   1. Steering Wheel Angle <120degree 2. Accelerator pedal position < 90% 3. Accelerator pedal position grad < 250%/sec   (AND)  The following input signals quality is OK   * Vehicle Velocity * Vehicle acceleration * Yaw rate * Steering wheel angle * Gas Pedal Position * Brake Pedal Position | VehSpdAvgHSC2 is within the range for respective modules(ie FCW,Prefill, Emergency brake etc)  (AND)  TrEstdGearHSCHSC2!=0xF/0xE/0xD/0x0  (AND)  Driver monitoring conditions:   1. StrgWhlAngHSC2 < 0x78(120deg) 2. AccelActuPosHSCHSC2 < 90% 3. Accelerator pedal position grad<250%/sec(**CAN signal not present in the CAN matrix**) |
| (Standby) | (OFF) | Engine Off/Ignition Off  OR  AEB Switch is set to OFF/FCW Switch is set to OFF  OR  The following input signal quality is NOT OK   * Vehicle Velocity * Vehicle acceleration * Yaw rate * Steering wheel angle * Steering wheel angle gradient * Gas Pedal Position | EnASSStaHSCHSC2=0x0(Engine OFF)/  EnRunAHSCHSC2=0x0(Currently these are two signals related go Engine running state. Customer need to clarify which is the correct Signal to be used)  (OR)  AEBSwReqHSC2=0x01(OFF)/  FCWSwReqHSC2= 0x01(OFF) |
| (Active) | (Standby) | Ego speed out of the speed range for respective modules (ie FCW,Prefill, Emergency brake etc)  OR  Current gear is not one of the forward gears OR  Any of the following Driver monitoring conditions become False   1. Steering Wheel Angle > 120degree 2. Accelerator pedal position > 90% 3. Accelerator pedal position grad > 250 %/sec | VehSpdAvgHSC2!=Not in Range(ie FCW,Prefill, Emergency brake etc)  OR  TrEstdGearHSCHSC2=0xF/0xE/0xD/0x0  OR  Driver monitoring conditions:   1. StrgWhlAngHSC2 >0x78(120deg) 2. AccelActuPosHSCHSC2 > 90% 3. Accelerator pedal position grad > 250 %/sec(**CAN signal not present in the CAN matrix**) |
| (Active) | (OFF) | Engine Off  OR  AEB Switch is set to OFF/FCW Switch is set to OFF  OR  The following input signal quality is NOT OK   * Vehicle Velocity * Vehicle acceleration * Yaw rate * Steering wheel angle * Steering wheel angle gradient * Gas Pedal Position * Brake Pedal position | EnASSStaHSCHSC2=0x0(Engine OFF)  / EnRunAHSCHSC2=0x0(Currently these are two signals related go Engine running state. Customer need to clarify which is the correct Signal to be used)  (OR)  AEBSwReqHSC2=0x01(OFF)/  FCWSwReqHSC2= 0x01(OFF) |

#### Critical Signals

* Vehicle Velocity
* Vehicle Acceleration
* Yaw Rate
* Steering Wheel angle
* Gas Pedal Position
* Gas Pedal Position gradient
* Brake Pedal Position
* Steering wheel angle gradient

# **3 **EBA Inhibition Conditions****

For the HARA, it shall be assumed, that low steering or low acceleration activity is not sufficient to inhibit EBA interventions. At least from safety point of view, a driver override mechanism shall be foreseen. Typical mechanisms are driver override by acceleration or driver override by steering.

The following table shows the conditions that will suppresses EBA function.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Velocity(m/s) | Steering angle gradient(°/s) | Steering angle(°) | GasPedalPosition(%) | GasPedalPositiongradient（%/s） |
| <5 | >200 | >120 | >90 | >250 |
| 5-15 | >Linear interpolated value |
| >15 | >40 |

*Table 3: Conditions to suppress EBA function*

Detail description of the deactivation conditions:

If the Steering angle > 120deg OR

Accelerator Pedal position > 90% OR

Accelerator pedal position gradient > 250%/sec OR

The Steering wheel angle gradient > Calculated interpolated value of the steering wheel angle grad

(Calculations are done based on the vehicle velocity. As shown in the table, if the Ego velocity is between 5m/s-15m/s, then the value of

Steering wheel angle gradient is interpolated. Steering wheel angle

Gradient has upper and lower bounds here.

Upper bound is 200deg/sec

Lower bound is 40deg/sec)

Braking is performed until predicted motion of the vehicles shows no further closing movement (relative acceleration has to be considered too) or until the maximum intervention time (5sec) is elapsed.

## ****3.1 Function Off****

De-activation of the EBA or FCW system should not be possible with a single push of a button.

## ****3.3.1 FCW Function Off****

The driver shall be able to deactivate and activate the FCW function. If driver switches off the FCW function, distance warning, forward collision warning and warning jerk shall be switched off.

Please note that the driver cannot switch off FCW by pressing the switch once, if driver presses the switch to OFF there should be a warning to the driver on the dashboard saying ‘To press again to switch off the FCW’

## ****3.3.2 AEB Function OFF****

The driver shall be able to deactivate and activate the EBA function.

If driver switches off the AEB function, prefill, threshold adaption and autonomous braking shall be switched off.

Please note that the driver cannot switch off AEB by pressing the switch once, if driver presses the switch to OFF there should be a warning to the driver on the dashboard saying ‘To press again to switch off the AEB’

## ****3.2 Function Active****

In ACTIVE state, the system shall send out the warning or braking request when all the conditions are fulfilled to trigger EBA function.

The brake system must select the maximum value between the driver requested deceleration and the EBA function requested deceleration.

## ****3.3 Function Passive****

As defined in EBA state flow. In STANDBY/PASSIVE state, the system shall not execute either warning or braking request. But the system shall monitor current ego vehicle velocity, gear information and other relevant conditions to activate the system.

# 4 Driver Sensitivity Setting

The warning sensitivity setting shall help the driver to find a suitable warning timing. For detailed information see the following Table.

|  |  |  |
| --- | --- | --- |
| Value of signal | Description | Comment |
| Early | High sensitivity, long warning distance, for driver who applies the brake with less braking force than normal | Level shall be tunable |
| Middle | Normal sensitivity, normal warning distance for drivers with normal braking force. | Level shall be tunable |
| Late | Low sensitivity, warning distance is short meaning the driver needs to brake harder than normal. | Level shall be tunable |

The sensitivity levels are decided based on the TTC (Time to collision values). We have the following

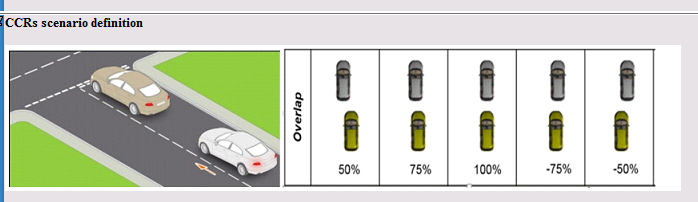
Definitions for the levels

|  |  |
| --- | --- |
| Sensitivity Levels | TTC values |
| EARLY | TTC<=1.2sec |
| MIDDLE | TTC<=0.9sec |
| LATE | TTC<=0.7sec |

The TTC values can be tuned as per the customer needs

# 5 Basic Use Case scenarios

1. **Approaching Stationary Target with various lateral offset**

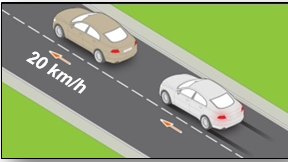


When the Ego vehicle is approaching the stationary target, with possible lateral displacement (overlap)

then the following function shall be output on the vehicle interface

* Forward Collision Warning
* Autonomous Braking

1. **Approaching Moving Target**



When the Ego vehicle is approaching a moving target, without the lateral displacement then the following function shall be output on the vehicle interface

* Forward Collision Warning
* Autonomous Braking

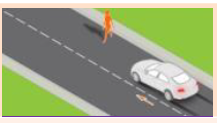
1. **Approaching Decelerating Target**



When the Ego vehicle is approaching a decelerating target, without the lateral displacement then the following function shall be output on the vehicle interface

* Forward Collision Warning
* Autonomous Braking

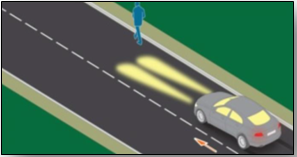
1. **Approaching crossing Pedestrian**



When the Ego vehicle is approaching a crossing pedestrian, following function shall be output on the vehicle interface

* Autonomous Braking

1. **Approaching longitudinal Pedestrian**



When the Ego vehicle is approaching a pedestrian, who is in the direction of Ego path with then following function shall be output on the vehicle interface

* Forward Collision Warning at 25% hit point
* Autonomous Braking up to 50% hit point

**Note that the performance of EBA on the pedestrians and the Bicycle is dependent on the sensor detection capability.**

# 6 NCAP Performance

According to SOR send by SGMW, the EBA system shall reach at least 70% for China NCAP 2018 test scenarios.

# 7 KPI

The KPI’s (False Positive Rates) for various sub functions of EBA is evaluated on the

following

* The recording database. (Currently we have the recordings which are run on the

European roads). So the algorithm will be validated against these recordings.

## 7.1 AEB system performance acceptation index

|  |  |  |
| --- | --- | --- |
| AEB system performance acceptation index | | |
| Function description | Performance item | KPI |
| AEB autonomous emergency Partial brake on Vehicle (deceleration <=5m/s2)  (under EuroNCAP test condition) | False trigger frequency for 100,000km | ＜1/100,000km |
| AEB autonomous emergency Full brake on Vehicle(deceleration > 5m/s2, for a duration < 350ms )  (under EuroNCAP test condition) | False trigger frequency for 200,000km | <1/200,000km |
| Forward collision warning on Vehicle | False trigger frequency for 5,000km | <2/5000km |
| AEB autonomous emergency Partial brake on Pedestrian(deceleration <=5m/s2)  (under EuroNCAP test condition) | False trigger frequency for 100,000km | ＜1/100,000km |
| AEB autonomous emergency Full brake on Pedestrian(deceleration > 5m/s2, for a duration < 350ms )  (under EuroNCAP test condition) | False trigger frequency for 200,000km | <1/200,000km |
| Forward collision warning on Pedestrian | False trigger frequency for 5,000km | <2/5000km |
| AEB autonomous emergency Partial brake on Cyclist(deceleration <=5m/s2)  (under EuroNCAP test condition) | False trigger frequency for 100,000km | ＜1/100,000km |
| AEB autonomous emergency Full brake on Cyclist (deceleration > 5m/s2, for a duration < 350ms )  (under EuroNCAP test condition) | False trigger frequency for 200,000km | <1/200,000km |
| Forward collision warning on Cyclist | False trigger frequency for 5,000km | <2/5000km |

Vehicle Prerequisites to achieve the above mentioned system performance are as follows:

1. Time until the locking pressure TTL <= 400ms
2. Max deceleration:10m/s2
3. Continental’s EBA function outputs deceleration requests on vehicle bus; no 3rd party software modules integrated

# 8 EBA Function Degradation

EBA function is degraded under the following conditions:

1. When the Ego vehicle enters the Tunnel or Car Park**.** Inside the Tunnel or Car park, there will be multiple reflections due to the closed walls and hence the object detections and object classifications would not be stable. Hence EBA performance would be degraded.
2. RADAR blockage:

EBA system shall monitor the sensor condition for performance. If there is a blockage in the sensor due to dirt or other environmental conditions, then object detection becomes difficult and are not reliable.

* If there is a blockage in Camera, then EBA cannot react on stationary VRU's(Pedestrian and Cyclist) and hence EBA performance is degraded.
* If there is a blockage in RADAR then then objects can no longer be detected

reliably and also the object related parameters(Object longitudinal distance,

object velocity etc) cannot be measured correctly and hence EBA is suppressed.

1. RADAR misalignment:

Performance of EBA ultimately depends on selecting target objects as soon as possible along the intended course of the ego vehicle. Therefore correct estimation of the ego course is critical to the performance. The estimation of ego course is greatly influenced by:

1. Alignment of the Sensor
2. Estimation of the ego curve

Therefore EBA continuously monitors the status of alignment and vehicle dynamics curve and keeps updating the distance until which EBA can reliably work.This distance is called the ***SafetyObjectDistanceEBA*.**

***SafetyObjectDistanceEBA*** = fn(Vehicle\_Dynamics\_Curve\_Error, Alignement\_Error(Elevation and Azimuth))

Higher the misalignment , then the safety distance keeps on decreasing and EBA cannot react on the objects whose

Longitudinal distance with respect to Ego vehicle is more than the Safety distance.

# 9 AEB function performance with respect to Fusion

AEB function performance with respect to Camera and Radar fusion is defined as follows:

|  |  |  |
| --- | --- | --- |
| Sensors | | Functions |
| Radar | Camera |
| Available/OK | Available/OK | Latent warning, FCW, Prefill, HBA, AEBCCRs, AEBCCRm,AEBCCRb,AEBC2P |
| Available/OK | Not available/NOK | Latent warning, FCW, Prefill, HBA, AEBCCRm, AEBCCRb. AEBCCRs is not available.  AEB on Pedestrian should be deactivated for warning and braking |
| Not available/NOK | Available/OK | All the functions should be deactivated |
| Not available/NOK | Not available/NOK | All the functions should be deactivated |

In the above table the terms OK/Available and NOK/Not available refers to the

Sensor detection quality, health check of the sensors and other relevant aspects.

# ****10 Driver Function Switch Actions****

Driver can activate or deactivate FCW and EBA on both Vehicles and Pedestrians through the function switch.

The following table illustrates the functionality of the ‘FCW Switch’

### 10.1.1 FCW Switch Actions

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Function switch actions | Warning Functions availability for vehicles | | | Warning Functions availability for Pedestrians | | |
|  | Latent Warning | FCW | Warning Jerk | Latent Warning | FCW | Warning Jerk |
| FCW Switch ON |  |  |  |  |  |  |
| FCW Switch OFF | x | x | x | x | x | x |

* **- Function available**

**X - Function not available**

### 10.1.2 AEB Switch Actions

As per the CAN matrix that is shared by the customer, we have two separate switches ie

* AEB on vehicle
* AEB on pedestrians.

So the below table defines the function availability as per the given input.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Function switch actions | | Braking Functions availability for vehicles | | | Braking Functions availability for Pedestrians | | |
| AEB\_Vehicle\_Switch | AEB\_Pedestrian\_Switch | Prefill | HBA | Emergency Brake(L1 /L2) | Prefill | HBA | Emergency Brake(L1 /L2) |
| AEB\_VEHICLE\_SW\_ON | AEB\_PED\_SW\_ON |  |  |  |  |  |  |
| AEB\_VEHICLE\_SW\_ON | AEB\_PED\_SW\_OFF |  |  |  | x | x | x |
| AEB\_VEHICLE\_SW\_OFF | AEB\_PED\_SW\_ON | x | x | x |  |  |  |
| AEB\_VEHICLE\_SW\_OFF | AEB\_PED\_SW\_OFF | x | x | x | x | x | x |

* **- Function available**

**X - Function not available**

# ****11**** ****AEB Specification for the HMI****

1. **Display specifications for Latent Distance Warning is as given below**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Function Name | Range | Units | Default Value | Conversion |
| EBALateralDistanceWarning | NA | NA | NA | $0=No Warning  $1=Warning |

When and only when the signal is $1, target information of “ACC target indicating 1”, “ACC target 2”, “ACC target 3” and “ACC target 4” will be restrained and will be displayed in accordance with the following requirements:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| EBALateralDistanceWarning State | Icon Display | | | Character Display | | Voice Reminder | | |
|  | Icon reference | Display Duration(s) | Display reference | Reference character | Display duration(s) | Alert frequency  (Hz) | Continuing duration(s) | Interval time(s) |
| $0 | NA | NA | NA | NA | NA | NA | NA | NA |
| $1 | The image is just for reference | ON | NA | Please Keep a Safe Distance | ON | NA | NA | NA |

1. **Display specifications for Forward Collision Warning is as given below**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Function Names | Range | Units | Default Value | Conversion |
| FCW | NA | NA | NA | $0=No Warning  $1=Warning |
| AEB Target Display/AEB Target Id | NA | NA | NA | $0=No Target  $1= Car  $2=Pedestrian  $3=Uncertain |

When and only when the signal is $1 and the signal of “AEB target display AEBTrgId” is $1, $2 and $3 , target information of “ACC target indicating 1”, “ACC target 2”, “ACC target 3” and “ACC target 4” will be restrained by IC and will be displayed in accordance with the following requirements:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| State of FCW | State of AEB Target Display | Icon Display | | | Character Display | | Voice Reminder | | |
|  |  | Icon reference | Display duration(s) | Display frequency | Reference character | Display duration(s) | Alert frequency(Hz) | Continuing duration(s) | Interval time(s) |
| $0 | $0  $1  $2  $3 | NA | NA | NA | NA | NA | NA | NA | NA |
| $1 | $0 | NA | NA | NA | NA | NA | NA | NA | NA |
| $1 | $1 |  | ON | NA | Please Brake | NA | NA | NA | NA |
| $1 | $2 | Front target is a Pedestrian(The image is just for reference) | ON | NA | Please Brake | NA | NA | NA | NA |
| $1 | $3 | Object not known | NA | NA | NA | NA | NA | NA | NA |

1. **Display specifications for AEB is as given below**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Function Names | Range | Units | Default Value | Conversion |
| AEB Active | NA | NA | NA | $0= Not active  $1=Active |
| AEB Target Display/AEB Target Id | NA | NA | NA | $0=No Target  $1= Car  $2=Pedestrian  $3=Uncertain |

When and only when the signal is $1 and the signal of “AEB target display AEBTrgId” is $1, $2 and $3 , target information of “ACC target indicating 1”, “ACC target 2”, “ACC target 3” and “ACC target 4” will be restrained by IC and will be displayed in accordance with the following requirements:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| State of AEB Active | State of AEB Target Display | Icon Display | | | Character Display | | Voice Reminder | | |
|  |  | Icon reference | Display duration(s) | Display frequency | Reference character | Display duration(s) | Alert frequency(Hz) | Continuing duration(s) | Interval time(s) |
| $0 | $0  $1  $2  $3 | NA | NA | NA | NA | NA | NA | NA | NA |
| $1 | $0 | NA | NA | NA | NA | NA | NA | NA | NA |
| $1 | $1 | The image is just for reference | ON | NA | AEB is active | NA | NA | NA | NA |
| $1 | $2 | Front target is a Pedestrian(The image is just for reference) | ON | NA | AEB is active | NA | NA | NA | NA |
| $1 | $3 | Object not known | NA | NA | NA | NA | NA | NA | NA |

1. **Display specifications for AEB is as given below**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Function/Feature Name | Range | Units | Default value | Conversion |
| AEB\_Fault | NA | NA | NA | $0 = False  $1 = True |
| When and only the signal is $1, AEB fault is displayed in the Instrument Cluster and the indicator light is red. Please find the below diagram for reference    The above diagram should be illuminated in red to indicate fault | | | | |

1. **AEB Target ID**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Function/Feature Name | Range | Units | Default value | Conversion |
| AEB\_TargetID | NA | NA | NA | $0=No Target  $1=Car  $2=Pedestrian  $3=Uncertain |
| When and only when the signal is $1-$3. The instrument cluster should display corresponding warning in accordance with functions ‘FCW’ and ‘AEB Active’ | | | | |

# 12 Limitations

1. The selection of the target object depends on the sensor quality and surrounding condition including
2. weather conditions, sensor blockage, road condition, driver behavior and so on .The function does not consider specific environmental conditions like actual friction of road (e.g. actual

friction, etc.).

1. The function might not avoid a collision in all cases. This depends e.g. on the brake system, the current

adhesion, the closing velocity.

1. EBA function cannot react on the Pedestrian who is waking alongside the traffic line or in the traffic line.
2. EBA function cannot react on the target vehicle on the same lane line, whose overlaps to the ego

vehicle is less than 50%.

1. EBA performance will be reduced due to overheated brake system.
2. EBA performance will be reduced due to latency and detection of the sensor. For example, radar cross

section of the object is too small so that sensor can’t confirm the distance between target and ego

object. EBA performance will be reduced due to calibration of the sensors. When possible, sensor shall be

calibrate again after crash or vibration.

# ****References****

1. ISO 15623-2013-Intelligent transport systems - Forward vehicle collision warning systems - Performance requirements and test procedures
2. ISO 22839 Intelligent transport systems — Forward vehicle collision mitigation systems - Operation, performance, and verification requirements
3. ISO 26262 Road vehicles — Functional safety
4. ISO 2675 Road vehicles — Symbols for controls, indicators and tell-tales
5. EuNCAP 2018 – Usecase references as per EuNCAP 18

In the case where this document is in conflict with any defined governmental issued regulations, the governmental regulations must and will take precedence.