

# Traceability Document

## Functional Requirements

- **FR1**-System should run diagnostic test for ABS failure on ignition
- **FR2**-System should notify driver and display signal light for ABS failure
- **FR3**-System should prevent from sudden wheel lock on applying
- **FR4**-System should shift to normal breaks if ABS fails
- **FR5**-System should reduce acceleration gradually upon applying ABS
- **FR6**-System should disable ABS if speed is below 20 km/h and vice versa

## High level and Low level Requirements

### **FR-1 System should run diagnostic test for ABS failure on ignition and display signal light:**

Upon ignition

- **HLR1.1** ECU should run diagnostic test on ABS system and check it's integrity
  - **LLR1.1.0** ECU should check if speed sensor is working
    - ECU should check toothed ring around RIM, inside breaks
  - **LLR1.1.1** ECU should check if modulator is working,
    - If modulator fails, controls shall be shifted to normal breaks
    - Or backup
  - **LLR1.1.2** ECU should check if hydraulic pump reading are correct (i.e. constraints to limit),
    - If faulty, controls shall be shifted to normal breaks
    - Or backup
  - **LLR1.1.3** ECU should check if enough power is available to apply ABS
    - Controller needs power for mechanism to work,
    - If no power is available, controls shall be shifted to normal breaks
    - Or backup
- **HLR1.2** If fault is found,
  - **LLR1.2.0** Try backup (analyze the speed using speed sensor, if it's working)
  - **LLR1.2.1** If that fails too,
    - Transfer controls to normal breaks
  - **LLR1.2.2** Notify the driver about ABS failure
    - Turing notification light on Drivers Assistant Control panel

### **FR2 System should prevent from sudden wheel lock on applying**

- **HLR2.1** ECU should sense the speed
  - **LLR2.1.0** Upon pressing the brake pedal,
  - **LLR2.1.1** ECU will take input,
  - **LLR2.1.2** Quick check integrity of system, if working or not
    - If not, shift the control to normal breaks
  - **LLR2.1.3** Obtain the speed of car from speed mechanism

- If not working, shift the control to normal breaks
  - If lower than 20km/h shift controls to normal breaks to prevent accident.
- **HLR2.2** Modulator should analyze the caliber of force being applied on hydraulic pump
  - **LLR2.2.0** If pump is not working, transfer control to normal breaks
- **HLR2.3** Modulator should press brake caliper with enough force that will stop the vehicle gradually rather than locking wheels
  - **LLR2.3.0** Check: if ABS fails, transfer control to backup or normal breaks.
  - **LLR2.3.1** Check force being applied,
  - **LLR2.3.2** Press brakes caliper accordingly,
  - **LLR2.3.3** Stop the car gradually
    - Prevent skidding.
- **HLR2.4** System should prevent wheel locking
  - **LLR2.4.0** See section **HLR2.1, HLR2.2, HLR2.3**

### **FR3 System should shift to normal breaks if ABS fails**

On applying breaks,

- **HLR3.1** ECU should quick check the integrity of ABS,
  - **LLR3.1.0** On start, see section 1.
- **HLR3.2** If there is something wrong, braking mechanism should be shifted to normal breaks
  - **LLR3.2.0** See section **FR2**

### **FR4 System should reduce acceleration gradually upon applying ABS**

On applying brakes,

\*assuming section 1 have been passed

- **HLR4.1** ECU should check if speed sensor is working (ABS depends upon it)
  - **LLR4.1.0** ECU should check toothed ring around RIM, inside breaks
  - **LLR4.1.1** If it's not working, transfer breaking controls to normal breaks
- **HLR4.2** Configure the modulators accordingly
  - **LLR4.2.0** Modulators are responsible for configuring braking pumps
  - **LLR4.2.1** If modulators aren't working, try backup.
- **HLR4.3** Apply enough pressure on brake calipers that it stops the car gradually;
  - **LLR4.3.0** See section **HLR2.3, HLR2.4**
- **HLR4.4** Prevent wheel to avoid skidding

### **FR5 System should disable ABS if speed is below 20 km/h and vice versa**

On applying brakes

- **HLR5.1** ECU should check speed of car, using speed mechanism
  - **LLR5.1.0** See section **HLR4.1**
  - **LLR5.1.1** See section **HLR2.1**

## Requirement based test-cases:

### Test-case FR1

#### THLR1.1:

- Run Diagnostics over ECU
  - **T1.1.1:** Check voltage from power source
    - Mutate voltage
  - **T1.1.2:** Ping speed sensor
    - Mutate speed
  - **T1.1.3:** Ping pressure sensor
    - Mutate pressure
  - **T1.1.4:** Check if modulator is working
    - Check if readings are correct (i.e. constraints)
    - Mutate readings

#### THLR1.2:

- **T1.1.5:** If fault is found
  - Switch to normal breaks

### Test-case FR2

#### THLR2.1

- **T2.1.1:** Speed Sensor
  - Start the vehicle
  - Simulate ECU
    - Run diagnostics
    - Simulate braking
  - Fetch speed from speed sensor
    - Ideally install two speed sensors while simulation to compare results
  - If speed isn't absolute
    - Making it erroneous by mutation
  - Mutate speed
    - Provide speed, provide boundary values
  - Switch to normal break as backup

#### THLR2.2

- **T2.2.1: Modulator/Speed Sensor/ hydraulic pressure**
  - Ignite the engine
  - Simulate ECU
    - Run diagnostics
    - Mutate ECU
  - Simulate speed

- Boundary values, random values
- Apply Breaks
  - Simulate the force applied on braking pedal
  - Mutate the pressure being applied
  - Simulate hydraulic pump
- If faults occur,
  - System shall Transfer controls to normal breaks

### THLR2.3

- **T2.3.1:** Pressure simulation
  - Ignite the engine
    - Run diagnostics
  - Apply breaks
    - Simulate pressure
  - Simulate ECU
  - Check speed
    - Mutate speed, test boundary values too (e.g.  $\leq 20$ )
  - Stop the car
    - If speed  $\leq 20$ , disengage ABS
      - Revert to normal breaks
    - If speed  $> 20$ , engage ABS and stop car gradually
    - Check for wheel lock
      - Rotation of wheel's movement shall be according to constraints
      - Mutate and create wheel lock situation
    - If wheels locked,
      - ABS failed.
  - If ABS fails
    - Switch to normal breaks or try backup (if any)

### THLR2.4

See section HLR 2.1, 2.2 and 2.3

### Test case FR3

#### THLR 3.1

- **T3.1.1:** Ignite the engine/simulator
- **T3.1.2:** Mutate pressure valve/ECU/speed sensor
- **T3.1.3:** Run diagnostics
  - Repeat test case FR1

#### THLR 3.2

- **T3.2.1:** Repeat HLR 3.1
- **T3.2.2:** Switch to normal breaks

## **Test case FR4**

### **THLR 4.1**

- **T4.1.1:** Ignite the engine
- **T4.1.2:** Run diagnostics
  - Check speed sensor
    - Introduce faults in speed sensor
  - Check pressure
    - Simulate according to constraints
- **T4.1.3:** Apply breaks
  - Fetch simulated values or from hardware (i.e. depends on type of testing)
- **T4.1.4:** If fault occurs,
  - Switch to normal breaks

### **THLR 4.2**

- **T4.2.1:** Ignite the engine
- **T4.2.2:** Run diagnostics
- **T4.2.3:** Repeat **T4.1.2**
- **T4.2.4:** Configure the modulator according to simulated values

### **THLR 4.3**

- Repeat Test cases HLR 2.3 and HLR 2.4

### **THLR 4.4**

- **T4.4.1:** Ignite engine
- **T4.4.2:** Throttle with speed greater than 20km/h
- **T4.4.3:** Lock wheels
- **T4.4.4:** Examine ABS

## **Test case FR5**

### **THLR 5.1**

- **Repeat 4.1**
- **Repeat 2.1**

## Traceability Matrix:

FReq.Id#	HReq.Id#	LReq.Id#	Inherited	Test cases
FR1	HLR1.1	LLR1.1.0		THLR1.1
		LLR1.1.1		
		LLR1.1.2		
		LLR1.1.3		
	HLR1.2	LLR1.2.0		THLR1.2
		LLR1.2.1		
		LLR1.2.2		
FR2	HLR2.1	LLR2.1.0		THLR2.1
		LLR2.1.1		
		LLR2.1.2		
		LLR2.1.3		
	HLR2.2	LLR2.2.0		THLR2.2
	HLR2.3	LLR2.2.0		THLR2.3
		LLR2.2.1		
		LLR2.2.2		
		LLR2.2.3		
	HLR2.4	LLR2.4.0	HLR2.1, HLR2.2, HLR2.3	THLR2.4
FR3	HLR3.1	LLR3.1.0		THLR 3.1
	HLR3.2	LLR3.1.1	FR2	THLR 3.2
FR4	HLR4.1	LLR4.1.0		THLR4.1
		LLR4.1.1		
	HLR4.2	LLR4.2.0		THLR4.2
		LLR4.2.1		
	HLR4.3	LLR4.3.0	HLR2.3, HLR2.4	THLR4.3
	HLR4.4	LLR4.4.0		THLR4.4
FR5	HLR5.1	LLR5.1.0	HLR4.1	THLR5.1
		LLR5.1.1	HLR2.1	