**BSPD on Shutdown Rev 2 Test Plan**

Project Revision 1 / Software Version

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## Summary

The Brake System Plausibility Device (BSPD) is a linear and logic system used to detect a fault with the brake system in different scenarios which will trigger the Low Voltage (LV) shutdown circuit of the tractive system (turn on/activate/ to shutdown). The integration of the BSPD with the shutdown circuit onto a single PCB allows the BSPD to monitor the major fault relays and send the corresponding signals to the shutdown system to prevent operation during unsafe/ major faulting scenarios. The 4 major faults monitored by the shutdown circuit are the BSPD\_FLT, BMS\_FLT, VCU\_FLT, and IMD\_FLT. Each fault is triggered by another set of signals indicating faults within the tractive system. We are looking at the BSPD\_FLT.

1.) The BSPD takes the CRT\_SENS input signal and compares it with a CRT\_REF\_HIGH(3.75V) and CRT\_REF\_LOW(1.25V) signal.

a. When the sensor signal is compared with the reference signal CRT\_REF\_HIGH, it will output the CRT\_SENS signal (as HIGH-1) if the sensor voltage is the larger signal and CRT\_REF\_HIGH (as LOW-0) if the sensor voltage is smaller than the reference signal. The output is now the CRT\_HIGH\_THRES signal. Ideally, we want this signal to be a LOW-0.

b. When the sensor signal is compared with the reference signal CRT\_REF\_LOW, it will output the CRT\_REF\_LOW (as HIGH-1) if the sensor signal is less than reference and output the CRT\_SENS (as LOW-0) if the sensor signal is larger than the reference. The output is now the CRT\_LOW\_THRES signal. Ideally, we want this signal to be a LOW-0.

c. The CRT\_HIGH\_THRES and CRT\_LOW\_THRES signals pass through an OR gate which will only output a LOW-0 signal if both input signals are LOW-0. All other conditions mean that the current sensor signal is not within threshold voltage and will result in a HIGH-1 signal output. Hence, we want this signal to be a LOW-0.

2.) The BSPD takes the BRAKE\_SENS input signal and compares it with a BRAKE\_REF\_HIGH(4.5V) and BRAKE \_REF\_LOW(1.5V) signal.

a. When the sensor signal is compared with the reference signal BRAKE \_REF\_HIGH, it will output the BRAKE \_SENS signal (as HIGH-1) if the sensor voltage is the larger signal and BRAKE \_REF\_HIGH (as LOW-0) if the sensor voltage is smaller than the reference signal. The output is now the BRAKE \_HIGH\_THRES signal. Ideally, we want this signal to be a LOW-0.

b. When the sensor signal is compared with the reference signal BRAKE \_REF\_LOW, it will output the BRAKE \_REF\_LOW (as HIGH-1) if the sensor signal is less than reference and output the BRAKE \_SENS (as LOW-0) if the sensor signal is larger than the reference. The output is now the BRAKE \_LOW\_THRES signal. Ideally, we want this signal to be a LOW-0.

c. The BRAKE \_HIGH\_THRES and BRAKE \_LOW\_THRES signals pass through an OR gate which will only output a LOW-0 signal if both input signals are LOW-0. All other conditions mean that the current sensor signal is not within threshold voltage and will result in a HIGH-1 signal output. Hence, we want this signal to be a LOW-0.

3.) The output signals from 1c and 2c pass through an AND logic gate which will output a HIGH-1 signal if neither current nor brake sensor signals meet threshold voltages. A LOW-0 signal output will result if both current and sensor signals meet threshold values, or if either sensor signal meet threshold values. The output is now the V LOGIC signal. LOW-0 desired.

4.) The V LOGIC output goes through an time delay circuit by approximately 40ns (datasheet) which can be thought of as the previous signal called V LOGIC DELAYED.

5.) A logic AND gate compares the V LOGIC (real time signal) with the V LOGIC DELAYED (previous signal) reading. If both signals are HIGH-1, this means that the current and brake sensor signals are not within threshold for an extend time (not instantaneous) so the logic gate will output a HIGH-1 voltage signal. If both signals are LOW-0, the continuous check on the current and brake sensors meet threshold values and the output will be a LOW-0. LOW-0 desired.

6.) An inverter circuit is used output the BSPD\_OUT signal. If the input is a HIGH-1 then the BSPD\_OUT will be ACTIVE LOW, an indication of a fault. This will open the switch and send a fault signal and will need to be reset. If the input is LOW-0 then the BSPD\_OUT will be ACTIVE HIGH, an indication that the current and brakes sensors meet safe operating conditions and no fault signal sent.

| ACTIVE HIGH | Gate Signal | Switch(Set/Reset) Close | No fault signal |
| --- | --- | --- | --- |
| ACTIVE LOW | No Gate Signal | Switch(Set/Reset) Open | Fault Signal Sent |

## Project Pictures

## Summary of Test

This test evaluates the operation of the BSPD circuit in outputting a constant active high/gate signal for current and brake sensor values within threshold and outputting an active low signal for current and/or brake sensor values falling out of the threshold ranges. Scenarios of current input and brake inputs being within range are tested for a gate signal output from the BSPD circuit. Scenarios of current and brake sensor voltages falling out of range (too low or too high) are tested for no gate signal output from the BSPD circuit.

## Test Being Performed

### Equipment/Lab Materials

2 Power supply (2 channels)

Breadboard (equivalent to the pcb)

LED (1) – 3V operating range

10 Ohm resistor (minimum value)

Wires/Alligator clips

Multimeter(For reading Voltage)

Soldering iron (maybe??)

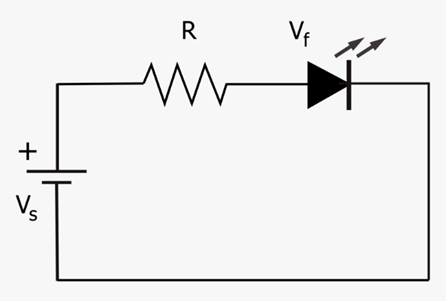
Test headers(male PCB headers)

Precautions:

### Procedure (Test Cases)

General Procedure:

1.) Construct simple LED-resistor circuit using BSPD output as the input. R = 10Ohm, Vs = BSPD\_OUT



2.) Connect CH1 of power supply to the CRT\_SENS to simulate current sensor input.

3.) Connect CH2 of power supply to BRAKE\_SENS to simulate brake sensor input.

4.) Ground everything.

**Case 1: Current Sensor and Brake Sensor within Range**

1.) Set CH1 voltage to 1.6V

2.) Set CH2 voltage to 3.0V

3.) Measure BSPD\_OUT voltage and record it. Record LED observations.

4.) Repeat step 1 using 1.5V, 1.7V, 1.9V, 2.1V, 2.3V, 2.5V, 2.7V, 2.9V, 3.1V, 3.3V, 3.5V, and 3.7V respectively. Keep CH2 constant.

5.) Set CH2 voltage to 1.3V

6.) Set CH1 voltage to 2.5V

7.) Measure BSPD\_OUT voltage and record it. Record LED observations.

8.) Repeat step 5 using 1.8V, 2.0V, 2.2V, 2.4V, 2.6V, 2.8V, 3.0V, 3.2V, and 3.4V respectively. Keep CH1 constant.

**Case 2: Current Sensor within Range, Brake Sensor out of Range (too low)**

1.) Set CH2 voltage to 1.5V

2.) Set CH1 voltage to 2.5V

3.) Measure BSPD\_OUT voltage and record it. Record LED observations.

4.) Repeat step 5 using 1.4V, 1.2V, 1.0V, 0.8V, 0.6V, 0.4V, 0.2V and 0.0V respectively. Keep CH1 constant.

**Case 3: Current Sensor within Range, Brake Sensor out of Range (too high)**

1.) Set CH2 voltage to 4.5V

2.) Set CH1 voltage to 2.5V

3.) Measure BSPD\_OUT voltage and record it. Record LED observations.

4.) Repeat step 5 using 4.6V, 4.7V, 4.8V, 4.9V, 5.0V, 5.1V, 5.2V, and 5.3V respectively. Keep CH1 constant.

**Case 4: Brake Sensor within Range, Current Sensor out of Range (too low)**

1.) Set CH1 voltage to 1.25V

2.) Set CH2 voltage to 3.0V

3.) Measure BSPD\_OUT voltage and record it. Record LED observations.

4.) Repeat step 1 using 1.2V, 1.0V, 0.8V, 0.6V, 0.4V, 0.2V, 0.1V, and 0V respectively. Keep CH2 constant.

**Case 5: Brake Sensor within Range, Current Sensor out of Range (too high)**

1.) Set CH1 voltage to 3.75V

2.) Set CH2 voltage to 3.0V

3.) Measure BSPD\_OUT voltage and record it. Record LED observations.

4.) Repeat step 1 using 3.8V, 4.0V, 4.2V, 4.4V, 4.6V, 4.8V, and 5.0V respectively. Keep CH2 constant.

**Case 6: Current Sensor (high) and Brake Sensor out of range (high)**

1.) Set CH1 voltage to 3.75V and Set CH2 voltage to 4.5V. Measure and record BSPD\_OUT and LED observations.

2.) Set CH1 voltage to 3.8V and Set CH2 voltage to 4.6V. Measure and record BSPD\_OUT and LED observations.

3.) Set CH1 voltage to 4.0V and Set CH2 voltage to 4.7V. Measure and record BSPD\_OUT and LED observations.

4.) Set CH1 voltage to 4.2V and Set CH2 voltage to 4.8V. Measure and record BSPD\_OUT and LED observations.

5.) Set CH1 voltage to 4.4V and Set CH2 voltage to 4.9V. Measure and record BSPD\_OUT and LED observations.

6.) Set CH1 voltage to 4.6V and Set CH2 voltage to 5.0V. Measure and record BSPD\_OUT and LED observations.

**Case 7: Current Sensor (high) and Brake Sensor out of range (low)**

1.) Set CH1 voltage to 3.75V and Set CH2 voltage to 1.5V. Measure and record BSPD\_OUT and LED observations.

2.) Set CH1 voltage to 3.8V and Set CH2 voltage to 1.4V. Measure and record BSPD\_OUT and LED observations.

3.) Set CH1 voltage to 4.0V and Set CH2 voltage to 1.2V. Measure and record BSPD\_OUT and LED observations.

4.) Set CH1 voltage to 4.2V and Set CH2 voltage to 1.0V. Measure and record BSPD\_OUT and LED observations.

5.) Set CH1 voltage to 4.4V and Set CH2 voltage to 0.8V. Measure and record BSPD\_OUT and LED observations.

6.) Set CH1 voltage to 4.6V and Set CH2 voltage to 0.6V. Measure and record BSPD\_OUT and LED observations.

**Case 8: Current Sensor (low) and Brake Sensor out of range (high)**

1.) Set CH1 voltage to 1.25V and Set CH2 voltage to 4.5V. Measure and record BSPD\_OUT and LED observations.

2.) Set CH1 voltage to 1.2V and Set CH2 voltage to 4.6V. Measure and record BSPD\_OUT and LED observations.

3.) Set CH1 voltage to 1.0V and Set CH2 voltage to 4.7V. Measure and record BSPD\_OUT and LED observations.

4.) Set CH1 voltage to 0.8V and Set CH2 voltage to 4.8V. Measure and record BSPD\_OUT and LED observations.

5.) Set CH1 voltage to 0.6V and Set CH2 voltage to 4.9V. Measure and record BSPD\_OUT and LED observations.

6.) Set CH1 voltage to 0.4V and Set CH2 voltage to 5.0V. Measure and record BSPD\_OUT and LED observations.

**Case 9: Current Sensor (low) and Brake Sensor out of range (low)**

1.) Set CH1 voltage to 1.25V and Set CH2 voltage to 1.5V. Measure and record BSPD\_OUT and LED observations.

2.) Set CH1 voltage to 1.2V and Set CH2 voltage to 1.4V. Measure and record BSPD\_OUT and LED observations.

3.) Set CH1 voltage to 1.0V and Set CH2 voltage to 1.2V. Measure and record BSPD\_OUT and LED observations.

4.) Set CH1 voltage to 0.8V and Set CH2 voltage to 1.0V. Measure and record BSPD\_OUT and LED observations.

5.) Set CH1 voltage to 0.6V and Set CH2 voltage to 0.8V. Measure and record BSPD\_OUT and LED observations.

6.) Set CH1 voltage to 0.4V and Set CH2 voltage to 0.6V. Measure and record BSPD\_OUT and LED observations.

### Results

Provide any and all qualitative and quantitative results obtained by the test. Any results, tables, graphs should be shown here as well as pictures of the test being performed.

### Functionality Check

Expected Results:

|  | Fault | BSPD\_OUT Voltage Reading | LED Observation |
| --- | --- | --- | --- |
| Case 1 | No Fault | Between 3.5 to 5.5V | LED ON |
| Case 2 | No Fault | Between 3.5 to 5.5V | LED ON |
| Case 3 | No Fault | Between 3.5 to 5.5V | LED ON |
| Case 4 | No Fault | Between 3.5 to 5.5V | LED ON |
| Case 5 | No Fault | Between 3.5 to 5.5V | LED ON |
| Case 6 | Fault | Between 0 to 1V | LED OFF (or very dim) |
| Case 7 | Fault | Between 0 to 1V | LED OFF |
| Case 8 | Fault | Between 0 to 1V | LED OFF |
| Case 9 | Fault | Between 0 to 1V | LED OFF |

Table with all the voltages they need to firmware team to program the

\*\*\*talk to firmware team to see what they need

Whoever working on BSPD and accelerator and brake pedal and ensure the test can provide them

Make sure BSPD works (validation) and Ensure it can properly integrate with software (and the hardware)

1. Assemble everything in a testable manner
2. Headers wires power supply connection
3. Bare table with results record on each case(excel or on test plan)
4. Have meeting (include Andrei)