# MY 2005 Honda Pilot Stability Assist Malfunction – Uncommanded Braking

Project 2193.PILOT/PE12-028/EA13-002

March 2013

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| **Project Number** | 2193.PILOT/PE12-028/EA13-002 |
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| **Date** | March 2013 |

# Honda Pilot Uncommanded Braking

# Introduction

- The National Highway Traffic Safety Administration (NHTSA), Office of Defects Investigation (ODI) received a defect petition (DP) on April 9, 1912. A consumer petitioned NHTSA to initiate a defect investigation of alleged stability control failures in model year (MY) 2005 Honda Pilot vehicles. The petitioner alleges that, "in the malfunctioning of these systems, steering failures occur and the brakes apply involuntarily." To support an investigation, an evaluation of complaint vehicles, including a 2005 Honda Pilot was performed by the Vehicle Research and Test Center (VRTC), at the request of ODI.
- Critical components of systems which control the brakes include:
  - Input sensors (wheel speed sensors, steering wheel angle sensors, the yaw rate sensor, lateral accelerometers) all are critical as they feed information into the electronic stability control (ESC) system.
  - In addition accelerator pedal signal(s), brake signal(s) and certain transmission parameters may also feed into the ESC system.
  - Power supplies and grounding schemes relating to these sensors are also critical in providing the right input to the sensors to the ESC system.
  - To complicate matters further, devices (capacitors, inductors and ferrite beads and other active and passive components) are used to provide conducted and radiated emissions protection to the sensors and/or control modules.
- The main control module for the MY 2005 Honda Pilot's Vehicle Stability Assist (VSA) system is the VSA module. in the MY 2005 Honda Pilot vehicles the VSA module integrates braking control strategies for anti-lock braking, traction control, electronic stability control and brake assist functions.

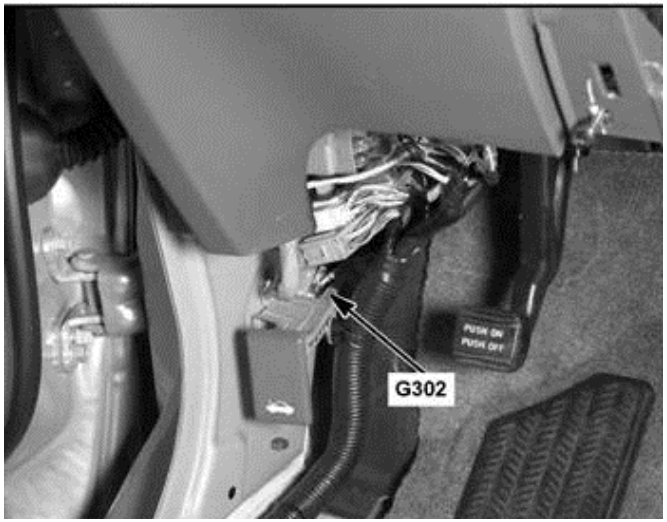
NOTE1: ODI Resume, DP 12-002, Date Opened, 06/04/2012, Subject: Vehicle Stability Assist Malfunction. This was subsequently closed, the petition having been granted and a preliminary investigation was opened as PE12-028./EA13-002
NOTE2: VOQ number 10459818, MY 2005 Honda Pilot VIN 5FNYF18515BXXXXXX. The vehicle receiving inspection was at VRTC on June 13, 2012.
NOTE3: Honda's name for the ESC system is the Vehicle Stability Assist (VSA) system.

# Background

- The **vehicle stability assist module (VSA),** the **yaw rate sensor** and/or a **VSA ground point (G302)** may be implicated with the malfunctions alleged by consumers. The Vehicle Stability Assist (VSA) system in the MY 2005 Honda Pilot vehicles integrates braking control strategies for anti-lock braking, traction control, electronic stability control and brake assist functions.
  - The system consists of a VSA modulator (an electronic control unit and electronic/ hydraulic actuator) that receives data from an integral brake pressure sensor and from wheel speed sensors (four wheels), the steering wheel angle sensor and a combination yaw rate and lateral acceleration sensor.
  - The yaw rate sensor can malfunction due to its ground integrity, a change in supply voltage or internal problems.
  - The G302 ground if not correctly connected, can cause changes in supply voltage to the VSA and the associated pump on the VSA.

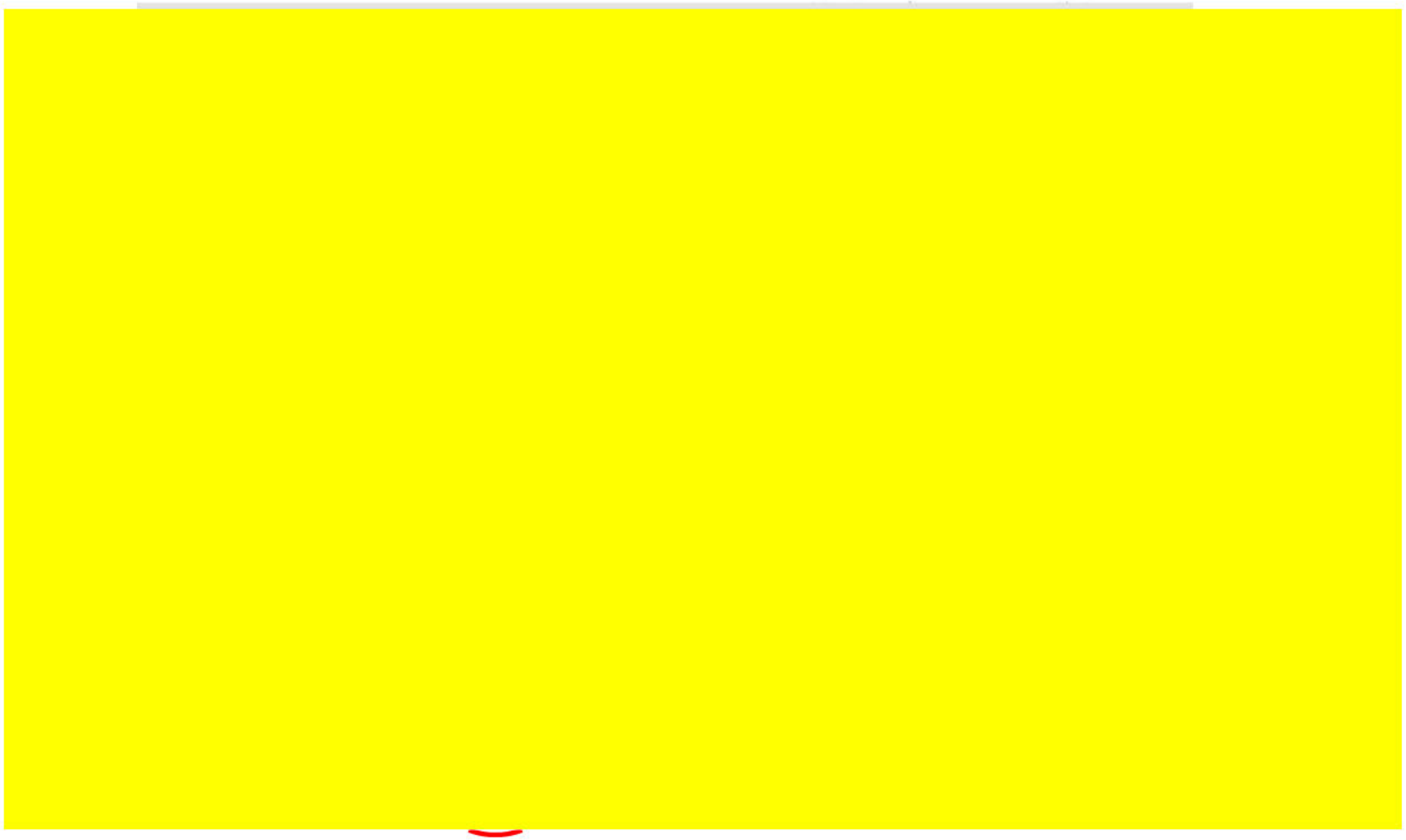
# Areas of Investigation - Grounding

- First we examined the ground connection, between the wire crimp on G302 and frame. We comment on the adequacy of the ground below, but the ground appeared to be functioning properly during an initial examination of the first vehicle (by measuring the voltage drop across the ground connection between the wire ring terminal crimp and the battery). The voltage drop was negligible for the vehicle tested.

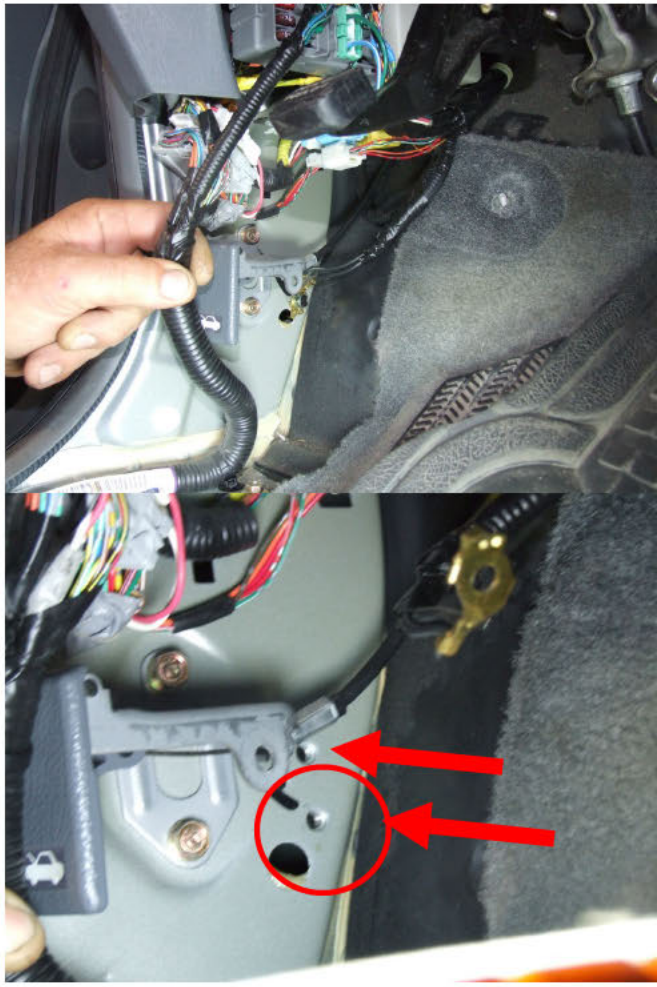



- A poor ground may also introduce noise on the speed sensor signals. The noise on the speed sensors could make it appear there is a higher wheel speed than actual. We have seen that the wheel speed values that were non-zero even though the vehicle was stationary. The higher than actual wheel speeds could trigger the traction control which would apply brakes on the wheels it thought were spinning. Alternatively, since the vehicle has a Variable Torque Management (VTM-4) system which with a noisy wheel speed signals may cause the VTM-4 to activate. If wheel speed noise is due to the bad ground causing the wheel speed signals that are fed from the Vehicle Stability Assist (VSA) to VTM-4 to be noisy. The signals within the VSA may be correct, but when the speed signals get to the VTM-4 they are noisy.

# Areas of Investigation - Grounding



# Notes on Grounding



# Notes on Grounding

- There is concern about the adequacy of the G302 ground to supply a ground reference to the VSA Modulator Control Unit and any associated sensors which rely on a ground from this module. The ground bolt for the VSA system may not be properly tightened.
- The ground currently under initial investigation, G302, consist of two separate connectors with ring terminal wire lugs crimped to another and fastened to the vehicle frame with a single threaded fastener. The vehicle frame is painted and grounding is only accomplished by the clamp load of the screw threads and the threaded through hole.
  - Per SAE, the metal surfaces shall be free of primer, paint, rust, and corrosion. An SAE recommended practice states: “The surface shall have a bright, polished appearance immediately before the ground terminal is connected.”
  - Furthermore, there is a second through hole in the frame in close proximity to the ground point in question which may have previously been used as a separate ground point.

- NOTE1: SAE Surface Vehicle Standard, J1908 REAF. NOV2007 Electrical Grounding Practice, Section 9.1 page 3.

# Notes on Grounding

- Adequate preparation and then protection of the faying surfaces of the wire lug and vehicle frame need to be considered in more depth. Dirt and debris, oxidation, vibration can cause loosening of the bolt attaching the ground.
  - Additional problems may arise due to the location of the ground point which is in close proximity to the floor mat and driver's foot. Moisture from the driver floor mat or snow or rain falling into the car could also further exacerbate the situation. Recommendations for proper grounding of electrical connections state: "ground connections made to metal surfaces shall maintain contact integrity with normal effects of aging, temperature cycling, moisture, splash, spray washing, fatigue, and other environmental connections" (Note 1).
  - Honda literature suggests that the cause of multiple diagnostic test codes (DTCs) including DTC 25 – yaw rate sensor, DTC 27-steering angle sensor, etc., may be caused by grounding issues. The article states "A poor ground G302 is the likely culprit. If this ground is loose or it's not making good contact because there's paint or debris under the terminal, you can wind up with an intermittent or complete loss of communication between the powertrain control module (PCM) , the VSA control unit and in the Pilot EX-Ls, the VTM-4 control unit. Make sure the terminal is clean and tight" (Note 2).

- NOTE1: SAE Surface Vehicle Standard, J1908 REAF. NOV2007 Electrical Grounding Practice, Section 9.0 page 3.
- NOTE2: Honda Service News, June 2005, Multiple VAS, VTM-4 and PGM-FI DTCs

# Testing Approach - Grounding

- After a subject vehicle goes through receiving inspection, diagnostic test codes (DTCs) on the vehicle are analyzed. Key parameters of the vehicle are instrumented for tracking. Then the vehicle is driven over a variety of test courses to simulate actual driving conditions. Throughout the driving program, no anomlies were noted and no uncommanded braking events occurred.
- Test methodology:
  - Additional resistance was put in series with the G302 ground, either in the pump motor circuit, the VSA module or both
  - After the majority of the driving tests, a brief evaluation of the effects of a poor ground at ground point G302 was made. Some minor hesitation occurred during the self-test of the brake boost pump, associated with low voltage due to the poor ground.
  - The actual effects of this hesitation could not initially be reconciled with the description of the braking events given by the owner. During this hesitation, the !-triangle and dash warning light blinked. Then the !-triangle and VSA light stayed on until the next key cycle.
  - Continuing testing, it was found that the right combination of events caused the Honda Pilot to react in a manner similar to that described by the vehicle owner.
  - While driving at various speeds, with a good ground, and going above a programmed self-test point (9 mph), the G302 ground was disconnected for less than a second.
  - Then the ground was reconnected but with resistance of less than 0.2 Ohm (a ground above 0.2 Ohm causes an immediate fault). The vehicle braked and would have stopped without a significant increase in throttle.

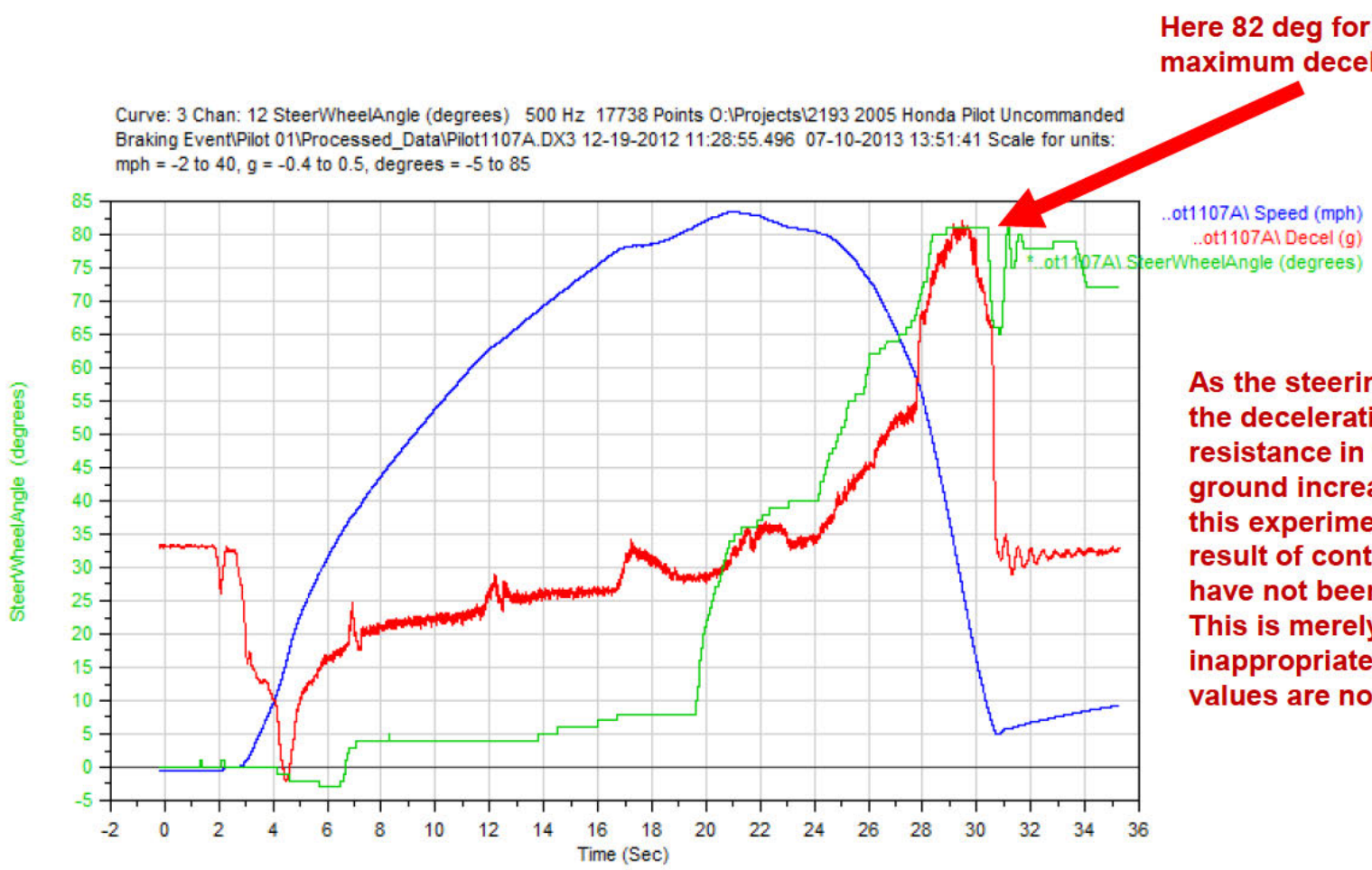
- For the first of three vehicles, initially upon receipt, DTCs indicating a possible grounding problem were observed but then did not reoccur during driving tests.

# Results – Grounding - Summary

| No. | Problem/Fault Injection | Vehicle Action | Results | Remarks |
|---|---|---|---|---|
| 1 | G302 ground high resistance, In series with the pump motor. | Straight line | No effect | No data taken for this run. |
| 2 | G302 ground high resistance, In series with the pump motor. | Straight line; intermittent ground | Intermittent braking | No data taken for this run. |
| 3 | G302 ground high resistance, In series with the VSA module. | Turning; intermittent ground | Intermittent braking | Resistance of 0.17 ohm to 0.21 ohm in the VSA ground circuit was worst case during tests. See Figures A & B.<br>Optimum steering wheel angle; Somewhere in the 100 to 150 degree range the VSA produces the largest inappropriate "intervention". See Figure C. |
| 4 | G302 ground high resistance, in series with the VSA module and the pump motor | Straight line; intermittent ground | Intermittent braking | No data taken. |
| 5 | G302 ground high resistance, in series with the VSA module and the pump motor | Turning; intermittent ground | Intermittent braking | See Figure D. |

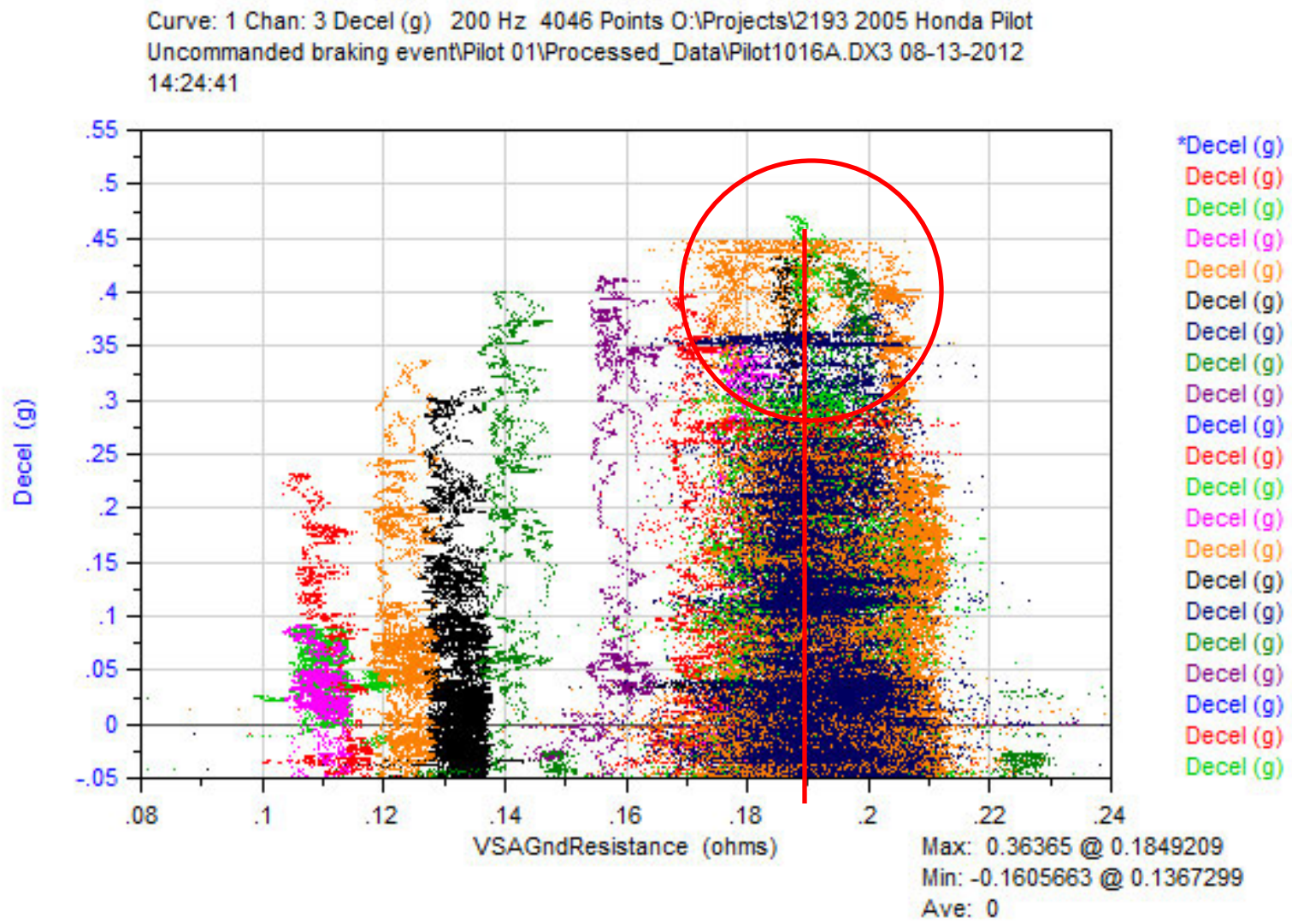
Note1: Ground tests involve opening connection, reconnecting (which resets module) and then applying intermittent increases in resistance.
Note2: Resistance of 1.9 ohms was typically used to simulate a problem with the ground.

# Figure A - G302 Series Resistance with VSA Module



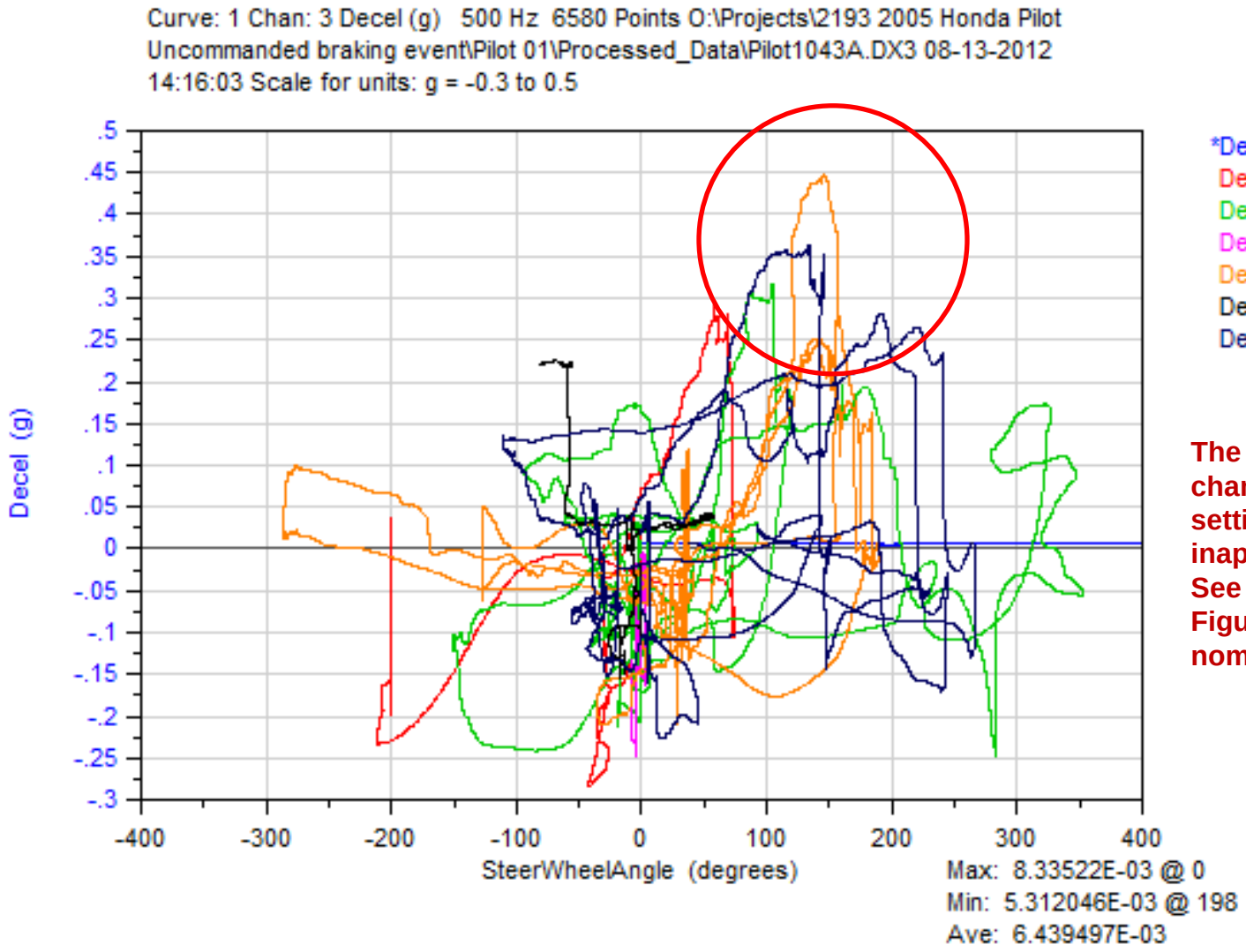

As the steering wheel is turned, the deceleration due to the series resistance in the VSA module ground increases. The results of this experiment are largely a result of control algorithms which have not been fully evaluated. This is merely an example of inappropriate intervention. All values are nominal.

# Figure B - G302 Series Resistance - Optimal Ground Resistance for Intervention



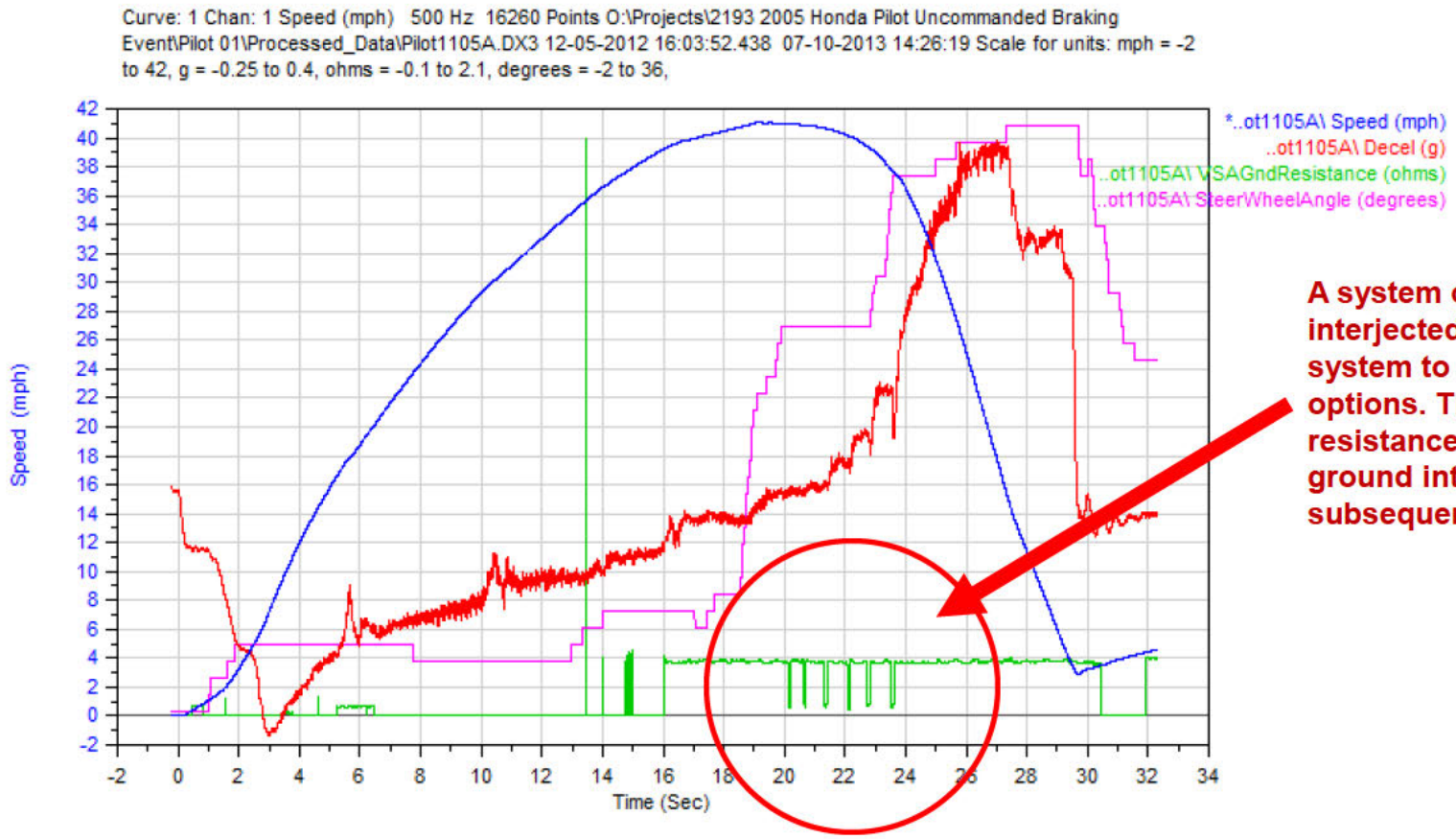

**Multiple runs were conducted, varying the resistance increase for the G302 ground. Maximum intervention occurred at approximately 0.19 ohms. All values nominal.**

# Figure C - Series Resistance Showing Optimal Steering Wheel Angle for Maximum Deceleration Intervention




**The steering wheel angle was changed to find the angle setting with the greatest inappropriate deceleration. See the single test case in Figure A. All values are nominal.**

# Figure D - G302 Resistance in Series with VSA and Pump



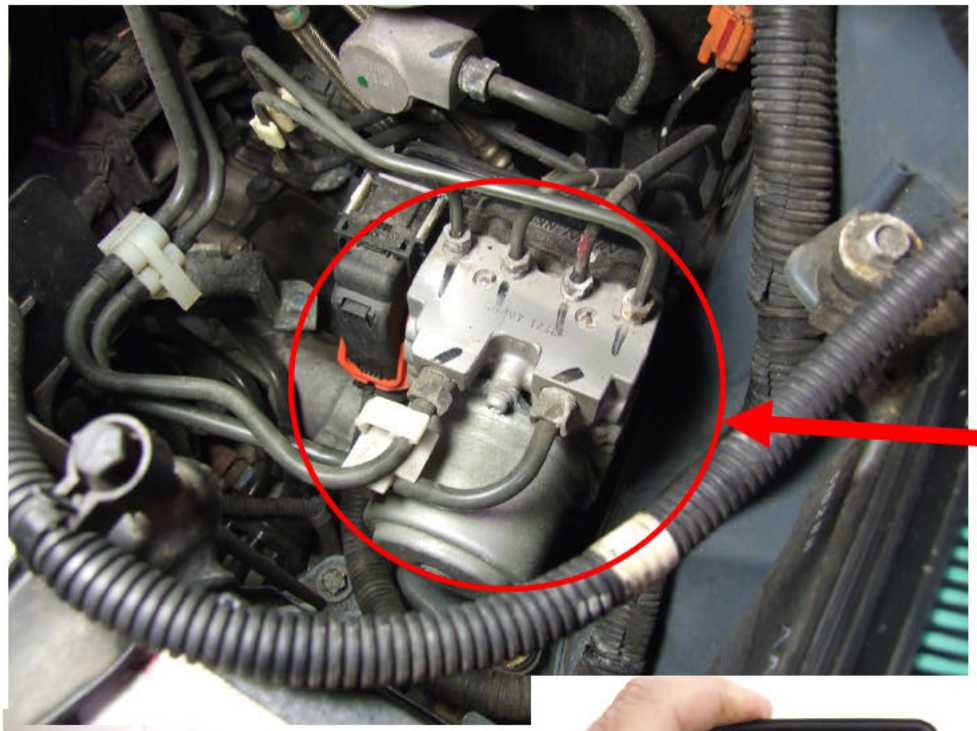

**A system on/off spike is interjected into the VSA system to reset self test options. Then intermittent resistance is introduced G302 ground into the system with subsequent deceleration.**

# Testing Approach – VSA Module

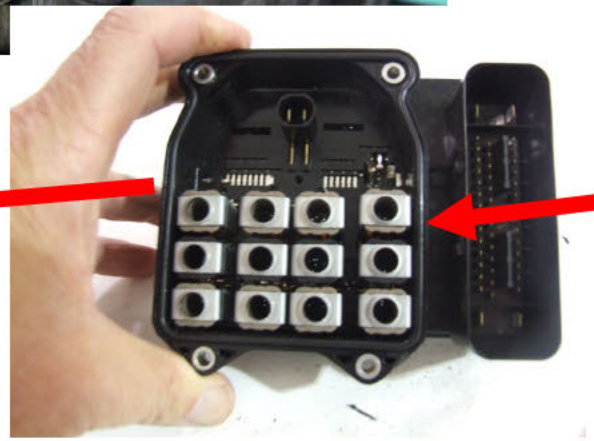
- The Vehicle Stability Assist (VSA) Module supplies/controls antilock brakes (ABS), traction control, electronic brake distribution (EBD), electronic stability control (ESC) called vehicle stability assist (VSA) in Honda vehicles, and brake assist.
- For brake assist, the VSA module is designed to detect rapid pressure increase from panic braking via a pressure sensor located within the VSA module.
  - If an electrical capacitor on the VSA control unit does not properly shield the pressure sensor in the VSA module from noise, the VSA system could malfunction and apply a small amount of brake force for a fraction of a second, without any input by the driver (this will be the main area of investigation).
  - Further, if the driver applies the brakes during a VSA system malfunction, full braking ensues until the pedal is released or the vehicle slows almost to a stop or to a complete stop.
  - Fluctuations in input voltage could also cause anomalous outputs of the pressure transducer.
  - The pressure transducer could itself malfunction.

# VSA Module

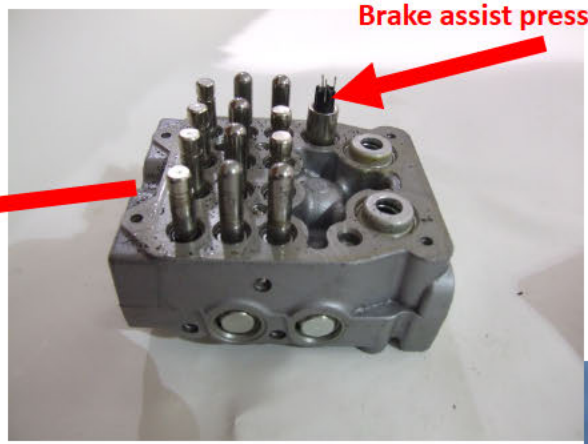
Vehicle Stability Assist Modulator
mounted in vehicle – air intake removed.



Vehicle Stability Assist Modulator
With brake lines removed.



Brake assist pressure sensor



# Areas of Investigation – Pressure Sensor

Vehicle Stability Assist Modulator

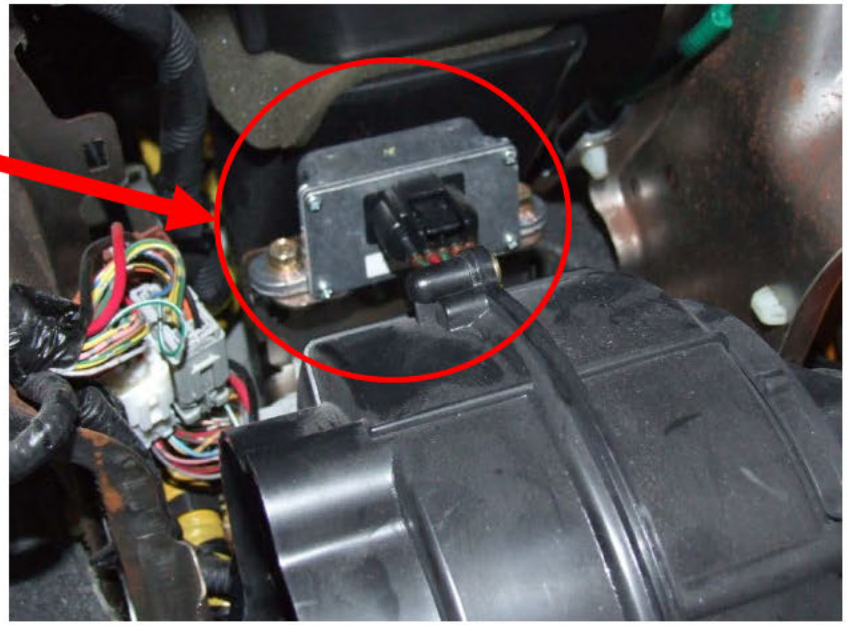
# Results – Yaw Sensor/VSA Module Summary

| No. | Problem/Fault Injection | Vehicle Action | Results | Remarks |
|---|---|---|---|---|
| 6 | Yaw rate sensor isolation | Straight line | No effect | We removed the chassis ground connection at the yaw rate sensor. If the ground is lost from VSA module to yaw rate sensor, then the output should go to 4.8 VDC. When the G302 ground is higher that the chassis ground, then a ground fault is "detected." See Figure E. |
| 7 | Chassis yaw rate negative. | Straight line | Brief minor intervention (brake actuation) and then faulted. | Pulling chassis ground (chassis of yaw rate sensor) is being pulled negative wrt vehicle chassis. See Figure F. |
| 8 | VSA module, pull up voltage | Straight line; no brake application, no brake light on. | Brief brake actuation | A voltage divider network is connected to the 5 VDC power supply to the VSA pressure sensor and to the output of the pressure sensor. By completing this circuit, the output of the pressure sensor rises imitating a "panic" braking event. See Figure G. |
| 9 | VSA module, pull up voltage | Straight line; brake application, brake light on | Full brake actuation | Same as above with brake pedal application. See Figure H. |
| 10 | Add, latent brake switch failure | Straight line; no brake application. Vehicle did not see extensive brake application. | Brief brake actuation | Simulated a failure in the normally closed (when brake released) set of contacts by disconnecting the connector at the brake pedal position switch, which caused the normally closed contacts to open and the normally open contacts to stay open all the time. Rapid brake stabs did not produce brake assist activation. Latent failure and pull up may cause intervention. This test was cancelled due to the Honda recall. |

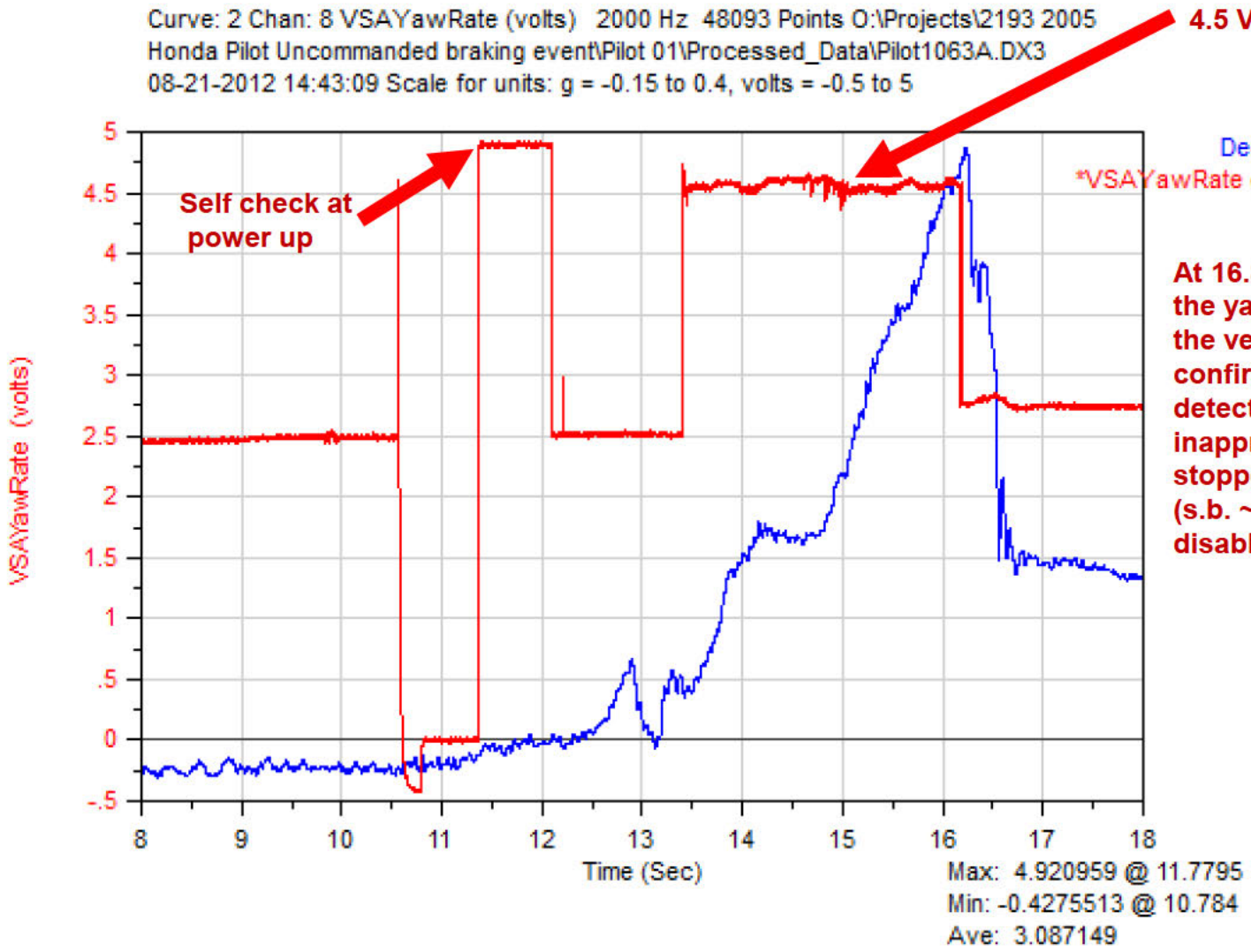
# Discussion – Yaw Rate Sensor Faults.

- The G302 ground can affect voltage input to the yaw rate sensor causing anomalous outputs. The yaw rate sensor is designed to output a +5 volts signal if it fails. With the G302 ground fault, voltage to the yaw rate sensor is lower that the expected input thus causing a failed output signal (now lower than expected) to be a valid signal. This may cause unexpected consequences to the VSA system.
- Additionally, loss of grounds to the yaw rate sensor may have other unexpected consequences.

Yaw rate sensor as mounted in the vehicle center counsel.

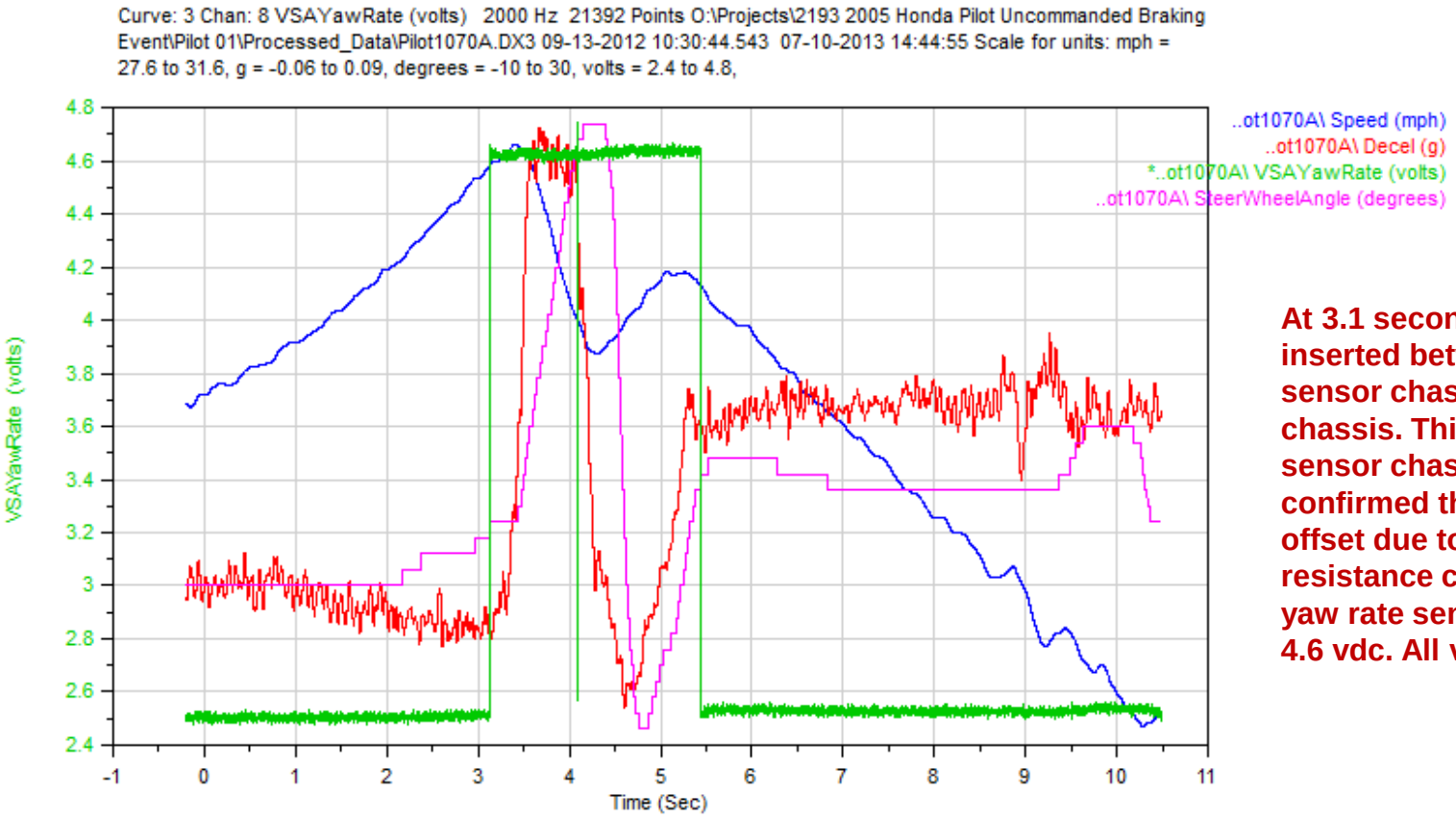


# Figure E - G302 Series Resistance with VSA and Pump and Yaw Rate Sensor Chassis Ground Removed @ 16.8 sec



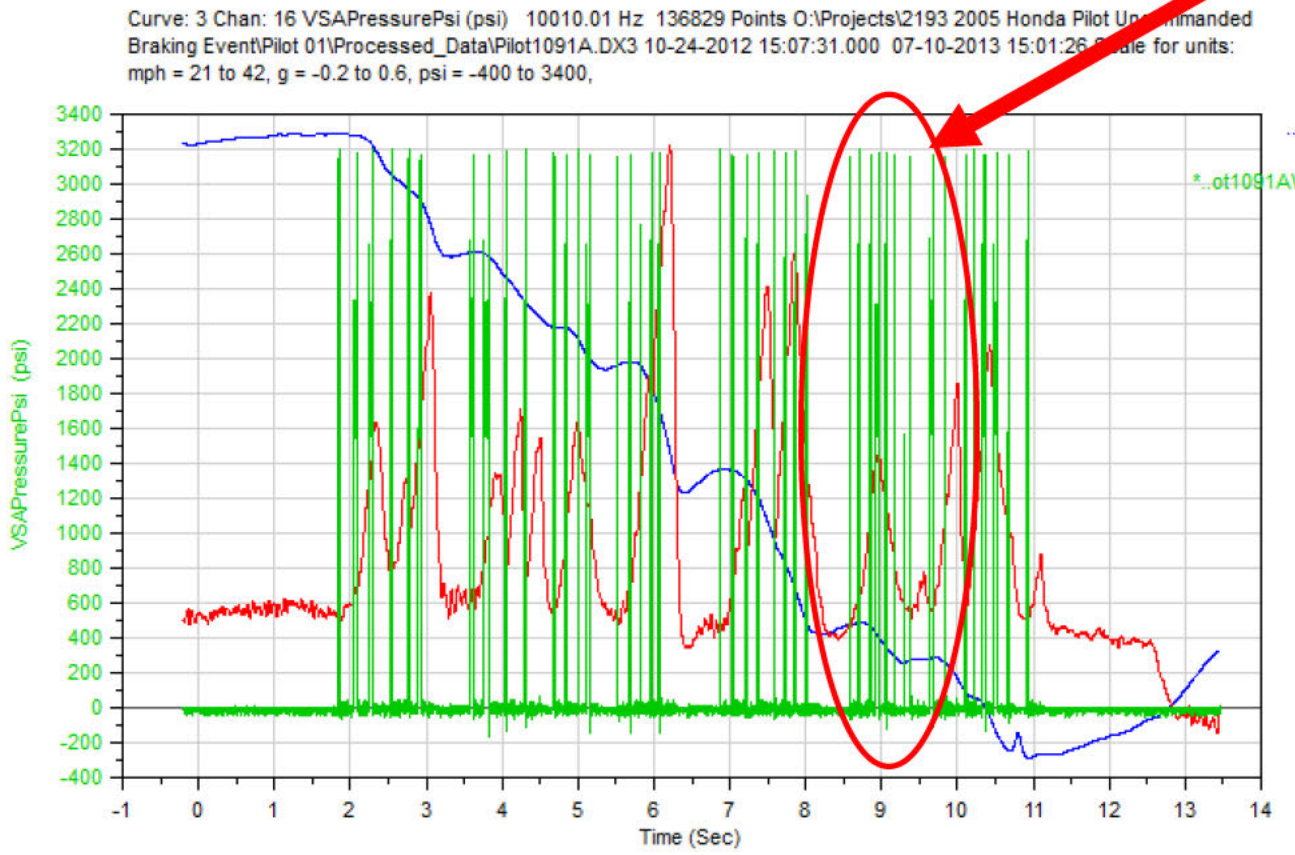

**At 16.8 seconds we disconnected the yaw rate sensor chassis from the vehicle chassis. This was to confirm that the ground fault detection circuit operated and inappropriate Intervention stopped. The output was 4.5 volts (s.b. ~5 volts) so the VSA was not disabled. All values nominal.**

# Figure F - Pulling Chassis of Yaw Rate Sensor Negative




**At 3.1 seconds, a 1.5 V battery is inserted between the yaw rate sensor chassis and the vehicle chassis. This takes the yaw rate sensor chassis negative. This confirmed that a VSA ground offset due to VSA ground resistance change caused the yaw rate sensor output to go to 4.6 vdc. All values nominal.**

# Figure G - Pull up Voltage simulating Noise on VSA pressure sensor w/o Brake Light Activation

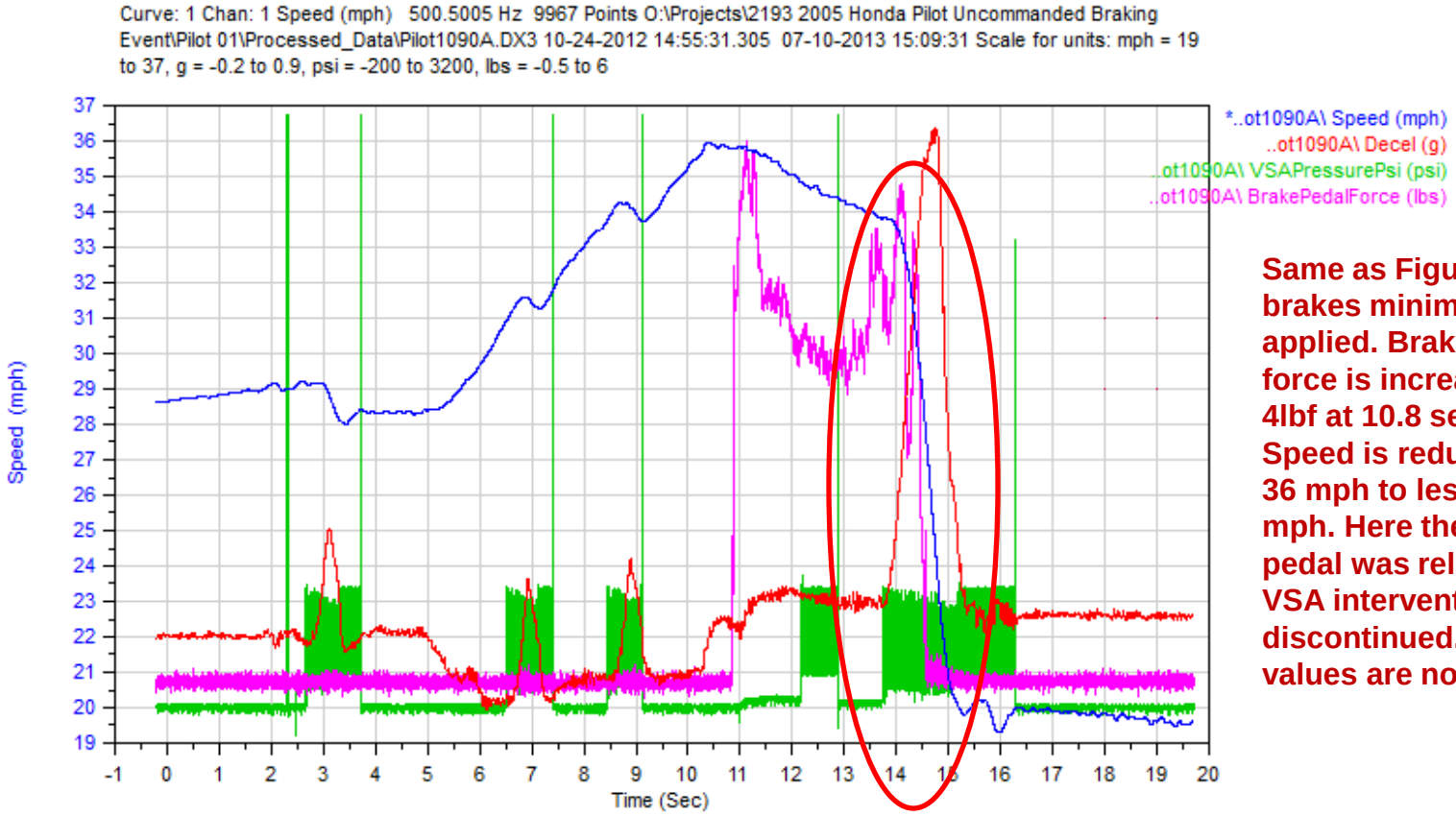



Typical simulated pressure increase to see system response. This is not necessarily the same result that would be caused by noise.

A voltage divider network is connected to the 5 VDC power supply to the VSA pressure sensor and to the output of the pressure sensor. By completing this circuit, the output of the pressure sensor rises imitating a "panic" braking event. All values are nominal.

(NOTE 1: No driver application of Brakes).

# Figure H-Pull-up Voltage Simulating Noise on VSA Pressure Sensor w Brake Light Activation & Rapid Speed Reduction




**Same as Figure G with brakes minimally applied. Brake pedal force is increased to ~ 4lbf at 10.8 seconds. Speed is reduced from 36 mph to less than 20 mph. Here the brake pedal was released so VSA intervention discontinued. All values are nominal.**

NOTE1: Brake light activation means that there was driver application of Brakes.

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