

Accuracy of Selected 2008 Ford Restraint Control Module Event Data Recorders

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ABSTRACT

The paper reports test results for accuracy of pre-crash speed, brake, and accelerator pedal position data recorded in a new family of Ford RCM EDR's under steady state conditions. The authors drove 2 test vehicles at 3 different speeds from 48 to 113 km/h (30 to 70 mph), and artificially created EDR events so pre-crash data would be stored. The authors collected RCM data and PCM data. A GPS based Racelogic VBOX was used to measure speed and record CAN bus information real time. Maximum error, average error, and 98% confidence intervals are reported for RCM to VBOX and PCM to VBOX. Accelerator pedal position accuracy and brake on/off reporting latency of the RCM to CAN bus data and/or auxiliary brake switches are documented.

INTRODUCTION

Prior papers have assessed the accuracy of pre-crash speed data in automotive event data recorders such as General Motors Sensing and Diagnostic Modules (SDM's). Chidester (1999) stated the accuracy was 4%. Lawrence (2003) tested vehicles using a 5th wheel and found SDM speed to be over reported by 1.5 km/h at low speeds and under reported by 3.7 km/h at high speeds up to 150 km/h. Niehoff (2005) reported on 28 crash tests from 40 to 64 km/h and determined the average error in pre-impact speed was 1.1% with a maximum error of 3.7%.

SOURCES OF VEHICLE SPEED IN EDR'S -

The source of vehicle speed information in the Ford vehicles tested is the transmission output shaft speed sensor. This sensor reports the average of the driven wheels. The raw signal is a DC coupled square wave that varies in frequency in proportion to vehicle speed. A typical specification would be expressed in Hz/Km/h, such as 1.3808 Hz/Km/h. The manufacturer's stated accuracy of the vehicle speed signal is +/- 2.5% +1 km/h for speeds 0-40km/h (25 mph) and +/- 2.5% for speeds >40 mph. The accuracy statement assumes the vehicle is equipped with factory specified tire sizes, without significant wear, at normal recommended tire pressures. The manufacturer's stated accuracy exceeds the legal speedometer requirements in the US of -3%/+7%. The raw vehicle speed signal is processed by one of the control modules in the vehicle (typically either the Body Control Module or the Powertrain Control Module (PCM)). Once the signal is processed, it is transmitted periodically across the Controller Area Network (CAN) bus and other modules receive it. The Restraint Control Module (RCM) retrieves a vehicle speed value periodically from the CAN bus and writes it in to a buffer in Random Access Memory (RAM). If the vehicle experiences a deceleration event meeting recording requirements, the vehicle speed is then written into the non-volatile EEPROM memory in the Restraint Control Module where it can be retrieved later. The Restraint Module is not creating the speed signal, it is simply recording what speed it is receiving from the source module transmitting it on the CAN bus.

2008 FORD FOCUS AND EDGE RESTRAINT CONTROL MODULE - The 2008 Ford Focus and Edge are both front wheel drive and use a Restraint Control

Module from the same family of modules. Both were tested. The event data recorder in this Restraint Control Module records pre-crash data including 5 data points of vehicle speed, brake on/off, and accelerator pedal position at 1 second intervals. Speed data is reported in the Bosch CDR report in both km/h and mph to the nearest 0.1. The vehicles are also equipped with an event data recorder in the Powertrain Control Module. The PCM contains 127 data points of speed, brake, accelerator pedal position and several other variables at 0.2 second intervals of the most recent time of operation (unless airbags deploy causing the record to be locked).

The test procedure consisted of accelerating the vehicle from stop to driving speeds of 48 to 113 km/h (30 to 70 mph), stabilizing the speed, and then applying brakes forcefully to simulate a panic stop situation. Approximately 2 seconds into the braking a non-deployment event was created on the test Restraint Control Module such that pre-crash data would be recorded. The test RCM was mounted to a fixture in the passenger foot well (or held on the passenger's lap). The fixture had springs and when the operator pulled the slide with the module on it back and then released it; the movable slide would accelerate due to the spring forces, and then strike the end of the fixture causing a sudden de-acceleration sufficient to create a non-deployment event. The factory equipped RCM was unplugged from the vehicle harness so it would not be altered by the testing and the vehicle could be returned to normal service after the testing. The vehicle end of the factory harness was plugged into a special wiring harness extender connecting vehicle power, ground, and CAN to the test module. The vehicle airbags were not connected during testing so as not to deploy them if a deployment event was created accidentally. The test RCM was mounted sideways, creating side impact events, because the module manufacturer indicated the module would not set side deployment events if no side satellite sensor was connected, and the same pre-crash data is generated as in a frontal non-deploy event. The target was to make 6 runs at each vehicle test speed.

During the 2008 Focus tests, six runs were made each with target speeds of 48.3 km/h (30 mph), 80.5 km/h (50mph), and 112.7 km/h (70mph). The 2008 Edge was intended to be subjected to the same series, but only 5 runs are available for comparison at 112.7 km/h (70 mph). For the Focus and Edge tests, actual vehicle ground speed was measured using differential GPS technology by a Racelogic VBOX II system operating at 10Hz. The Racelogic VBOX specification sheet claims accuracy of 0.1 km/h when averaged over 4 samples. The VBOX was a factory demo unit which is calibrated periodically and had a current calibration certificate. An additional pedal-mounted brake switch input was used to allow better data synchronization to the RCM and PCM data.

The VBOX was also set up to record vehicle CAN bus data for vehicle speed, brake on/off and accelerator

pedal position. The test procedure was also designed to permit verification that when the accelerator pedal was released and the brake applied, that EDR correctly recorded the accelerator pedal release and the brake application. Subsequent to each run, as soon as the vehicle was stopped the ignition key was turned off and the Powertrain Control Module (PCM) data was read out using Bosch CDR on the Edge and Ford proprietary tools on the Focus. The Ford PCM data was also compared to the VBOX data. While the Ford PCM accuracy has already been demonstrated in three other test vehicles in SAE 2008-01-0162, this paper serves to add two additional vehicles that have been specifically tested.

While speed data was gathered in both the steady state pre-brake application period and during the dynamic simulated panic braking, the scope of this paper is limited to assessing the accuracy of speed information during the steady state period. Dynamic accuracy will be addressed in future publications.

RESULTS

2008 FORD FOCUS RCM VS. RACELOGIC VBOX II - The RCM vs. VBOX data taken during steady state operation (prior to brake application) is shown in **Figure 1** (48 km/h/30mph), **Figure 2** (80 km/h/50mph) and **Figure 3** (113 km/h/70mph).

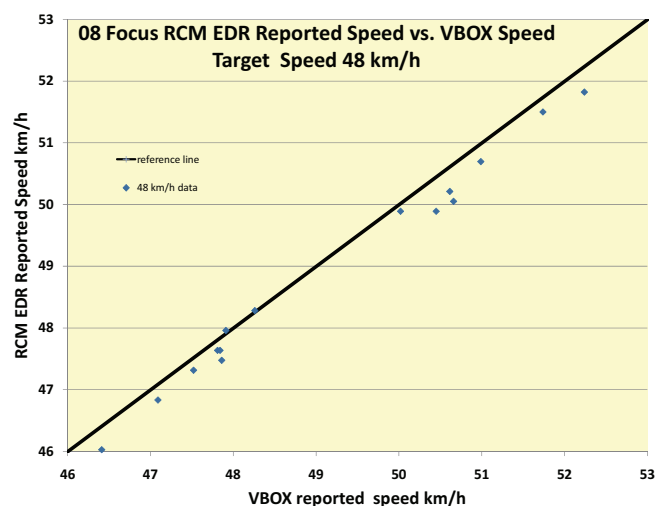


Figure 1 – Focus at 48 km/h target speed

The maximum difference between the VBOX and RCM at 48 km/h (30 mph) was -0.61 km/h (-0.38 mph) or -1.2%. The average difference was -0.28 km/h (-0.17 mph) or -0.6% and the standard deviation was 0.19 km/h (0.12 mph). The 98% confidence interval (+/- 3 sigma limit) was from -0.85 to 0.29 km/h (-0.53 to 0.18 mph) or -1.7% to +0.6%.

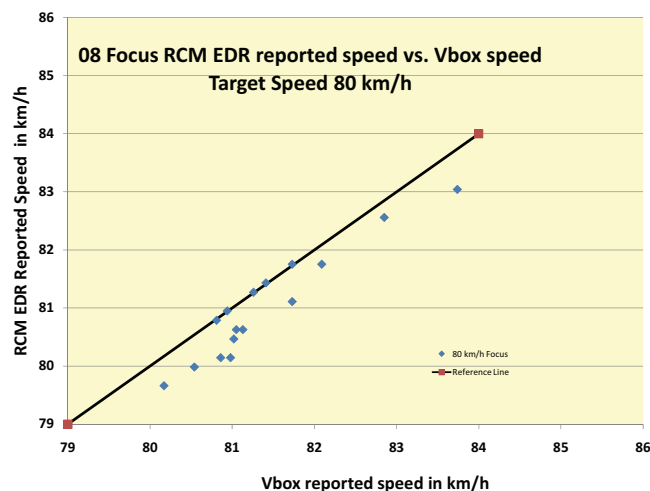


Figure 2 – Focus at 80 km/h target speed

The maximum difference between the VBOX and RCM at 80 km/h (50 mph) was -0.83 km/h (-0.52 mph) or -1.0%. The average difference was -0.37 km/h (-0.23 mph) or -0.5% and the standard deviation was 0.30 km/h (0.19 mph). The 98% confidence interval (+/- 3 sigma limit) was -1.27 to +0.53 km/h (-0.79 to 0.33 mph) or -1.6% to +0.7%.

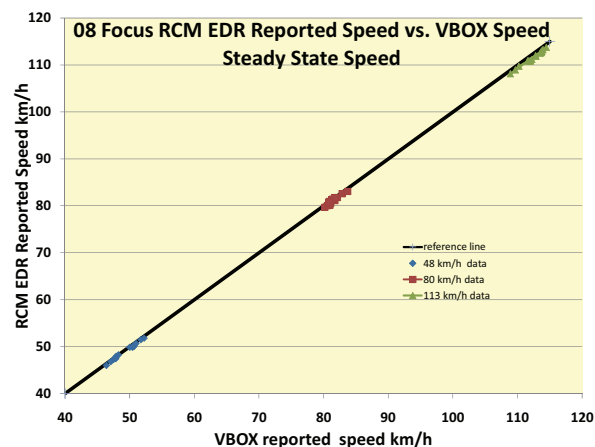


Figure 4 – Focus All Speeds

The data in **Figure 4** is the same information as in figures 1-3 but combines it all into one graph to better display the overall accuracy of the data.

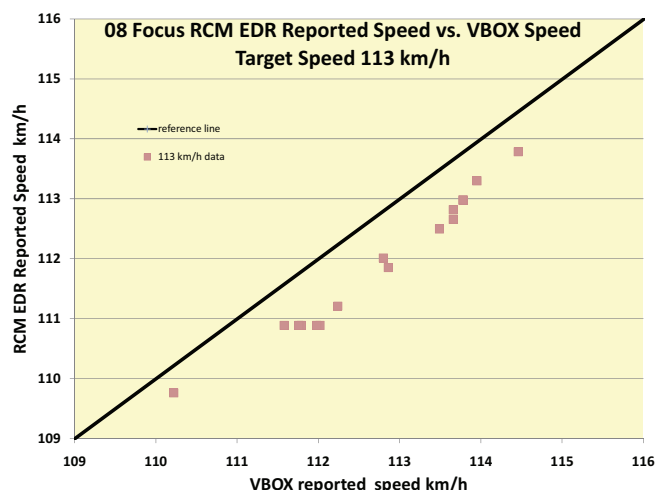


Figure 3 – Focus at 113 km/h target speed

The maximum difference between the Vbox and the RCM at 113 km/h (70 mph) was -1.14 km/h (-0.71 mph) or -1.0%. The average difference was -0.85 km/h (-0.53 mph) or -0.8%. The standard deviation was 0.18 km/h (0.11 mph) and the 98% confidence interval (+/- 3 sigma limit) was -1.39 to -0.31 km/h (-0.86 to -0.19 mph) or -1.2% to -0.3%.

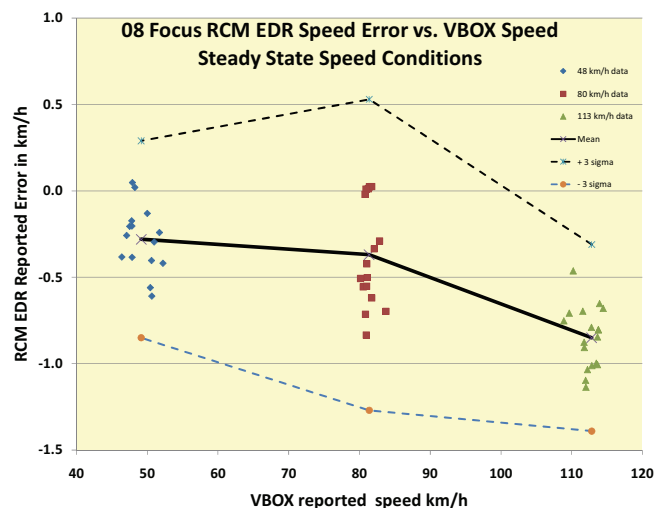


Figure 5 – Focus RCM/VBOX Error

98% confidence intervals (+/- 3 sigma range) are shown graphically in **Figure 5**.

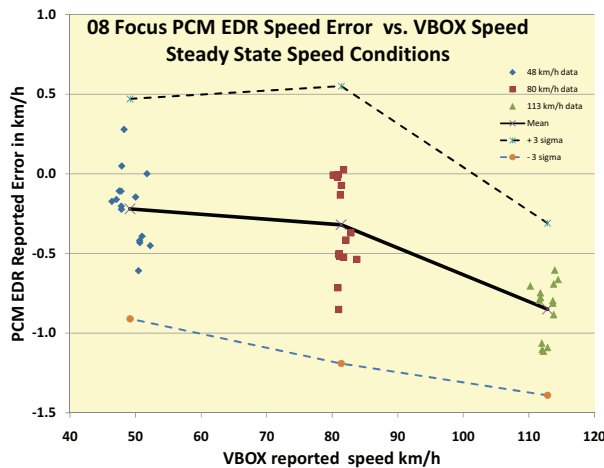


Figure 6 – Focus PCM/VOX Error

Focus Powertrain Control Module (PCM) speed data is compared to VOX data in **Figure 6**. Since the RCM records speed data reported by the PCM across the CAN bus, the correlation was expected to be very similar. The primary difference is the reporting frequency (every 0.2 second versus every 1 second) and the potential offset in time between when the points may have been recorded. So far, this analysis is only of the points aligning with the RCM data. Because the VOX records every 0.1 second and the PCM records every 0.2 second, more data points could be compared if necessary.

The maximum difference at 48 km/h between the VOX and the PCM was -0.61 km/h (-0.38 mph) or -1.2%. The average error was -0.22 km/h (-0.14 mph) or -0.4%. The standard deviation was 0.23 km/h (0.14 mph) and the 98% confidence interval (+/-3 sigma limit) was -0.91 to +0.47 km/h (-0.57 to +0.29 mph) or -1.9% to +1.0%.

The maximum difference at 80 km/h between the VOX and PCM was -0.85 km/h (-0.53 mph) or -1.0%. The average error was -0.32 km/h (-0.20 mph) or -0.4%. The standard deviation was 0.29 km/h (0.18 mph) and the 98% confidence interval (+/-3 sigma limit) was -1.19 to +0.55 km/h (-0.74 to +0.34 mph) or -1.5% to +0.7%.

The maximum difference at 113 km/h between the VOX and the PCM was -1.11 km/h (-0.69 mph) or -1.0%. The average error was -0.85 km/h (-0.53 mph) or -0.8%. The standard deviation was 0.18 km/h (.11 mph) and the 98% confidence interval (+/-3 sigma limit) was -1.39 to -0.31 to km/h (-0.86 to -0.19 mph) or -1.2% to -0.3%.

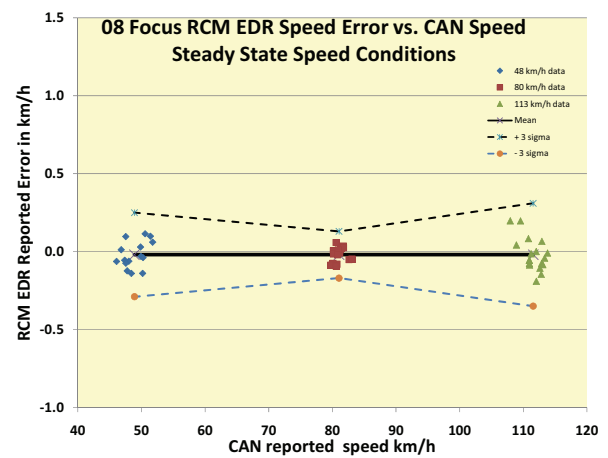


Figure 7 – Focus RCM/CAN Error

CAN bus speed data was monitored and compared to the RCM recorded values in **Figure 7**. The CAN bus is the source of the RCM data so correlation is expected, but because of small differences in sampling times some small differences are expected.

At 48 km/h, the maximum difference between CAN speed and RCM recorded speed was -0.14 km/h (-0.09 mph) or -0.3%. The average difference was -0.02 km/h (-0.01 mph). The standard deviation was 0.09 km/h (0.06 mph). The 98% confidence interval (+/-3 sigma limit) was from -0.29 to +0.25 km/h (-0.18 to +0.16 mph).

At 80 km/h, the maximum difference was -0.09 km/h (-0.06 mph) or -0.1%. The average difference was -0.02 km/h (0.01 mph). The standard deviation was 0.05 km/h (0.03 mph). The 98% confidence interval (+/-3 sigma limit) was from -0.17 to 0.13 km/h (-0.11 to 0.08 mph).

At 113 km/h, the maximum difference was +0.20 km/h (0.12 mph) or 0.2%. The average difference was -0.02 km/h (0.01 mph). The standard deviation was 0.11 km/h (0.07 mph). The 98% confidence interval (+/-3 sigma limit) was from -0.35 to 0.31 km/h (-0.22 to +0.19 mph).

2008 EDGE RCM VS. RACELOGIC VOX II - The RCM vs. VOX data taken during steady state operation (prior to brake application) is shown in Figure 8 (48 km/h/30mph), Figure 9 (80 km/h/50mph) and Figure 10 (113 km/h/70mph).