



**PROTERRA**



# TECHNICAL SERVICE BULLETIN

<b>ISSUE DATE:</b>	8-11-2020
<b>SERVICE BULLETIN SUBJECT:</b>	Duopower Powertrain Software Update
<b>VINs or MODELS AFFECTED:</b>	Service Specified Buses
<b>COMPLETE BY:</b>	Next Service Opportunity
<b>SERVICE BULLETIN #:</b>	SC-20-115
<b>LABOR OPERATION CODE:</b>	PP41Z

**NOTICE! It is expected that this process will require 1 hour per bus. Please schedule appropriately to minimize vehicle downtime.**

## POWERTRAIN SOFTWARE UPDATE

### Description

This procedure updates the Powertrain software to the latest version for improved powertrain performance. A White Paper showing an overview is provided at the end of this document.

# Summary of Software Changes

## Improvements

1. Increased allowed regen torque to improve efficiency.
2. Increased allowed motoring torque to improve acceleration and gradeability.
3. Increased regen in default Drive and Low modes to promote more efficient driving. Previous calibrations are still available using Proterra Diagnostic Tool configurations.
4. Various calibration changes to improve pedal response time, reduce drivetrain induced jerk in certain conditions, and improve low speed “clunk” during pedal tip-in.
5. Revised startup and shutdown sequence to improve robustness to quick ignition (key) cycles.
6. Regen re-enable criteria post ABS event revised to allow re-enable without coming to a stop.
7. Revised shutdown criteria to allow for ECU to shut down when a transmission is stuck in gear.
8. Modified oil pump control to provide flow to both transmissions at the highest rate needed for either transmission to protect against possibility of oil pump connectors being swapped.
9. Shifts selector display logic revised to only display “D” if a single forward mode is allowed to improve driver interface.
10. Recalibrated loss of communication with body controller diagnostic (SPN 2033, FMI 9) to reduce nuisance faults.
11. Recalibrated low power diagnostic (SPN 3357, FMI 1) to eliminate false positives under certain startup conditions.
12. Revised motor torque diagnostic (SPN 9061 and 9062, FMI 0) to reduce potential for false positives.
13. Modified transmission output speed diagnostics (SPN 191 and 9481, FMI 2) to reduce false positives

## New Features

1. Implemented acceleration limiting with modes for Eco, Nominal, and Max.
2. New motor check when drivetrain is enabled to ensure torque accuracy. Note, the motors are spun during the test and may be heard. Shifting is prohibited (flashing shift selector display) until test is complete; approximately 5 seconds after the drivetrain is enabled.
3. Support for motor and inverter pairing via Proterra Diagnostic Tool for field inverter or motor replacements.

## Bugs

1. Fixed bug inhibiting a change to allowed forward operating mode configuration.
2. Corrected torque application calibrations for reverse to match drive.
3. Recalibrated accelerator pedal input to ensure ability to reach 100% pedal position.
4. Corrected issue that would clear stuck in gear diagnostic when Proterra Diagnostic Tool was active.
5. Fixed issue allowing rapid torque application when releasing the interlock with the accelerator pedal depressed.
6. Revised torque application to eliminate motors spinning in neutral in certain operating conditions.

## Tools/Parts Required

- Customer Service Laptop with Proterra Diagnostic Tool
- Nexiq USB Link2 Device

### Parts Required:

- 054999 SOFTWARE, POWERTRAIN, 800V, DuoPower, v1.3.0 1 EA

## Connect to the Vehicle to Start the Proterra Diagnostics Tool

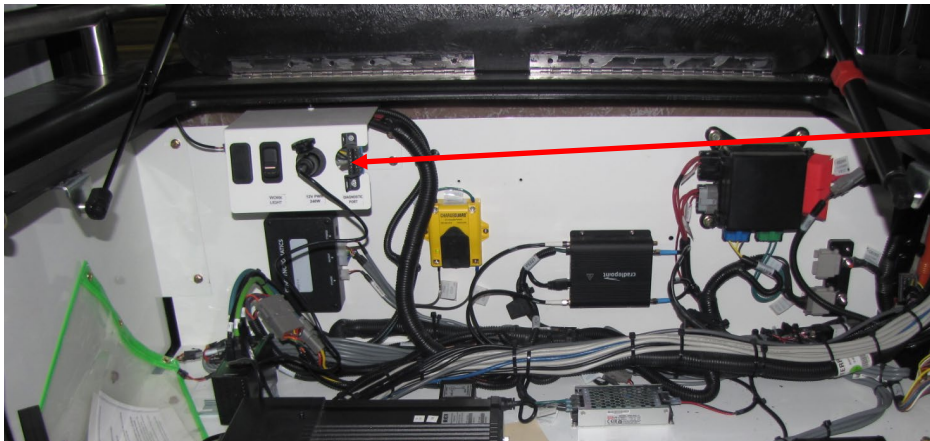
This process will guide the user to connect to the vehicle with the Proterra Diagnostics Tool.

1. Turn **ON** the 12/24V rear Vehicle Master Disconnect located behind the vehicle curbside rear charge port access panel.
2. Turn **ON** the bus Master Run Switch at the Driver's Workplace and ensure the Dash screen is **ON** to display "KEY ACC".



Master Switch  
"ACC"

3. Open the Streetside wheel well box to access to the OBDII Port.



OBDII Port

4. Power up (boot) the Proterra-supplied laptop containing the Proterra Diagnostic Tool.
5. Connect the Nexiq USB Link2 device to the laptop and to the appropriate OBDII Diagnostic Port.

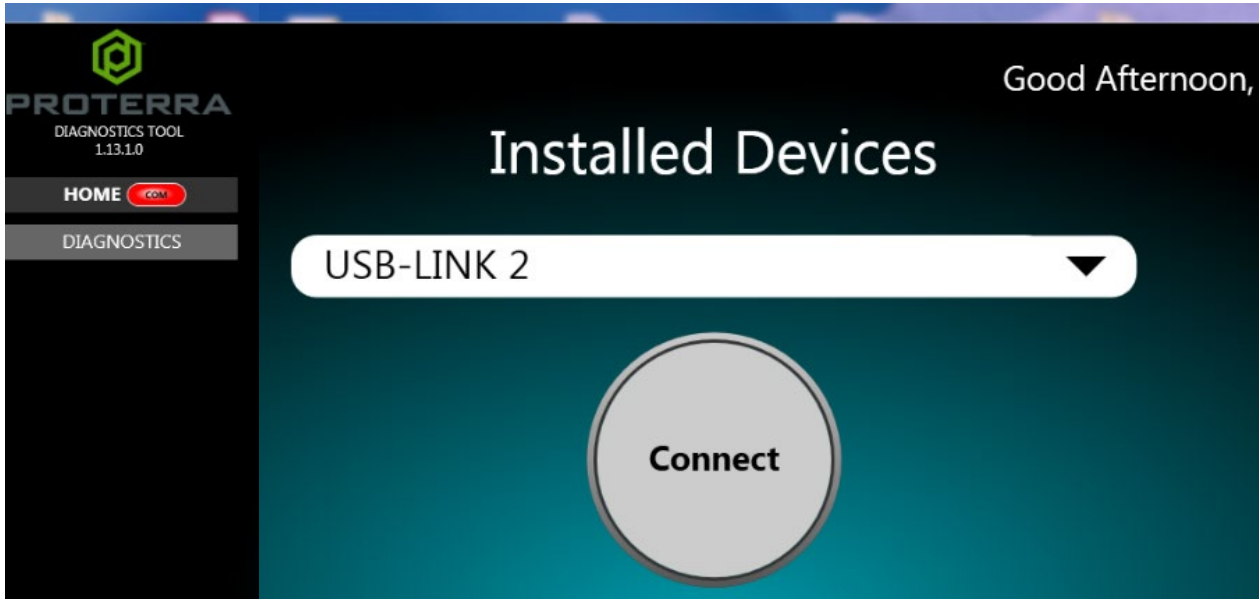


6. On the laptop, double-click on the Proterra Diagnostics Tool software icon to start the software.

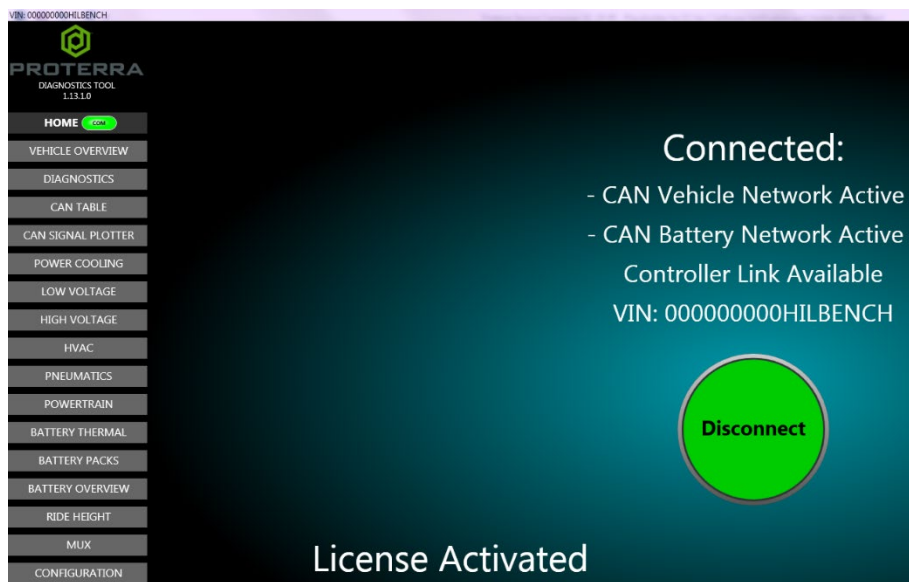


7. When the program opens, read and click OK for the prompt.

8. On the Home tab, select the appropriate device from the drop down and click "Connect".



9. Once the diagnostic tool has connected to the vehicle, you will have a VIN number and connection status displayed on the home screen, and tabs available to navigate.



## Update Powertrain Software

This procedure updates the Powertrain software version and maintains the Powertrain parameter configuration data across the flash download of new software.

1. Ensure you have the latest software file **054999.hex** in a known location on the service technician's computer (Folder or Desktop).  
**IMPORTANT!** NEVER access the software from a remote server or from a USB memory device, ALWAYS copy the software files to your computer hard drive and access the software from this location. It is recommended that you copy the entire "service bulletin files" folder to your local machine in order to more effectively keep track of the software versions you are deploying:  
<\\bus.local\files\Engineering\Service Bulletins\Service Bulletin Files for SC-20-115>
2. Turn **ON** the 12/24V rear Vehicle Master Disconnect located behind the vehicle curbside rear upper access panel.
3. Turn **ON** the bus Master Switch at the Driver's Workplace and ensure the Dash screen is **ACC**.



Master Switch "ACC"

4. After connecting to the vehicle using the Proterra Diagnostic tool at the **front OBDII Port (SSWW Box)**, navigate to the Configuration Tab.
5. Wait at least 10 seconds after starting the tool, then click the "Get Parameters" button at the top of the page.
  - a. **NOTE: This ensures that we have a backup copy of the original configuration parameters stored in a "zip" file, contained in the C:/Logs folder on your computer in case we need to refer to it later.**

Body Parameters			IMPORT PARAMS	GET PARAMETERS
Name	Access Level	Value		
High Voltage Connection S	1	3		
Daylight Savings Time Acti	1	1		
Fire Detection System Lock	1	0		
Pnumatic Leakage Rate Au	4	0		
Main Electronics Pump Run	4	127		
Lower Battery Pump Run Ti	4	0		
Air Compressor Run Timer	4	0		
Pnumatic Leakage Rate Pri	4	0		
DCDC Enable Swap	1	1		
Electric Doors Detected	1	0		
Collision Alert System Date	1	1		

6. Click on the “SOFTWARE VERSION” button at the bottom left of the screen. Verify that the Body Controller Software is version 6.3.0.

**Note:** If it is not Protterra Service Campaign SC-20-91 must be performed on the vehicle before proceeding.

The screenshot shows the Protterra Diagnostics Tool interface. On the left is a navigation menu with 'SOFTWARE VERSION' selected. The main area is titled 'Demo' and shows the date and time '8/18/2020 11:00:27 AM (Eastern Daylight Time)'. It is divided into two sections: 'Controller Software Versions' and 'BMS Software Versions'. The 'Controller Software Versions' section lists: Body Controller SW Version: 6.3.0 (circled in red), Powertrain Controller SW Version: 2.2.0, Vehicle Controller SW Version: 0.0.0, Charge Controller SW Version: Unknown Version, ESM Controller SW Version: Unknown Version, DC-DC SW Version: Unknown Version, ABS SW Version: Unknown Version, and Inverter SW Version: 4.12.9. The 'BMS Software Versions' section lists: S1P1 SC SW Ver: 15191005, S1P1 Main SW Ver: 15191006, S1P2 SC SW Ver: 15191005, S1P2 Main SW Ver: 15191006, S2P1 SC SW Ver: 15191005, S2P1 Main SW Ver: 15191006, S2P2 SC SW Ver: 15191005, and S2P2 Main SW Ver: 15191006.

Click Software Version

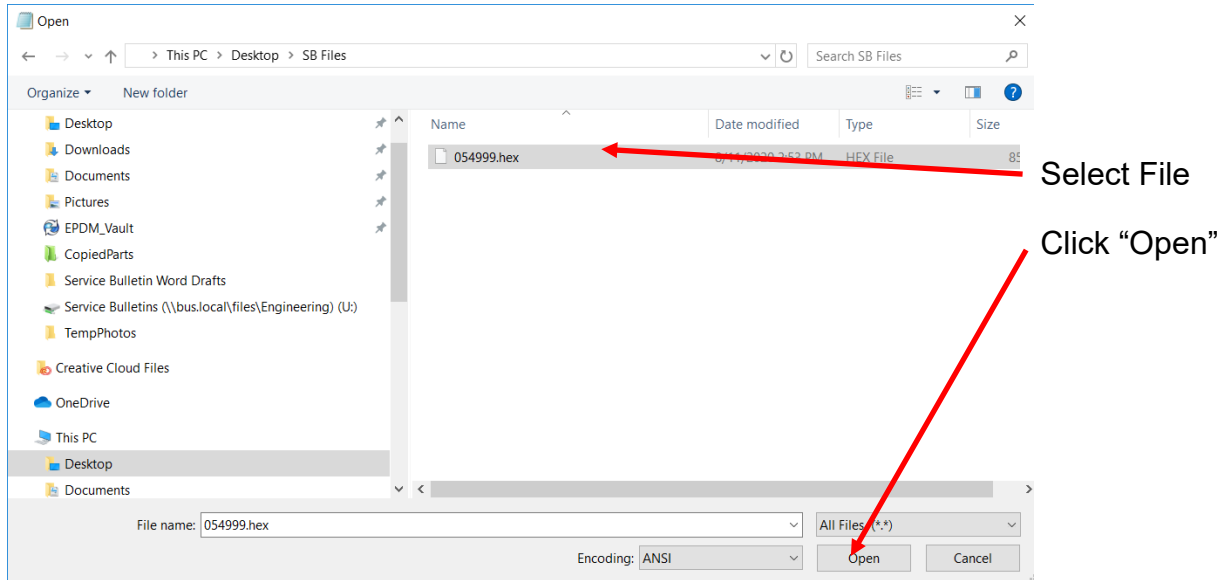
7. Now we are ready to click the Powertrain Firmware “Start Flash” Button.

The screenshot shows a 'WRITE' section with 'Current:' and 'New Value:' fields, where the 'New Value' is set to 0. Below this are several buttons for different components: 'Body Firmware', 'Powertrain Firmware', 'Charge Controller', 'Battery Master Controller', 'Battery Management System', and 'DC/DC Configuration'. Each of the first five buttons has a 'START FLASH' button next to it. A red arrow points to the 'START FLASH' button for 'Powertrain Firmware'.

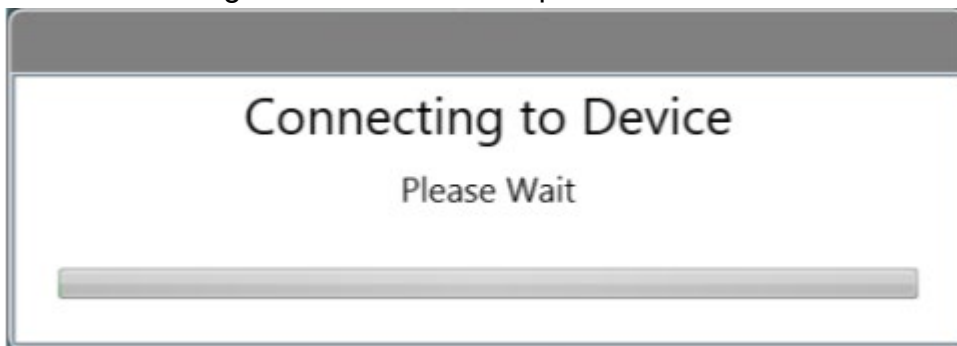
Click Powertrain Start Flash

8. The following screen will be displayed. Navigate to the location where you stored the configuration file earlier. Select the software file downloaded previously and click “Open” to load the file.

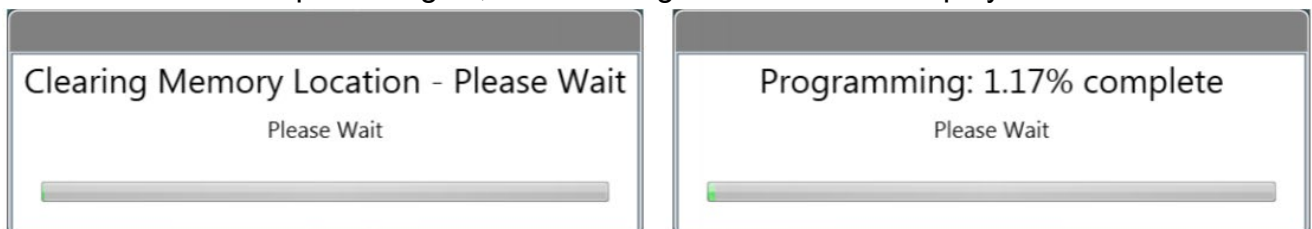
**Note:** The file name displayed should be 054999.hex.



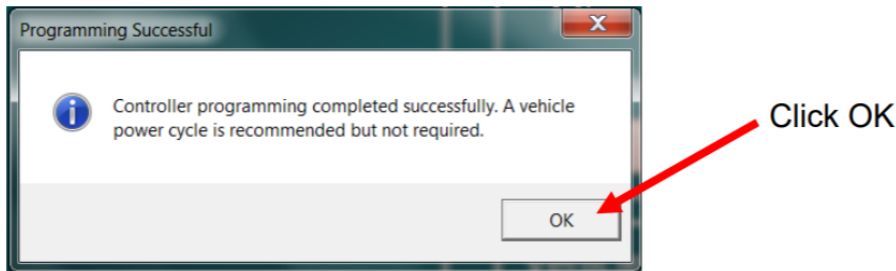
9. The Proterra Diagnostic Tool will attempt to connect to the device.



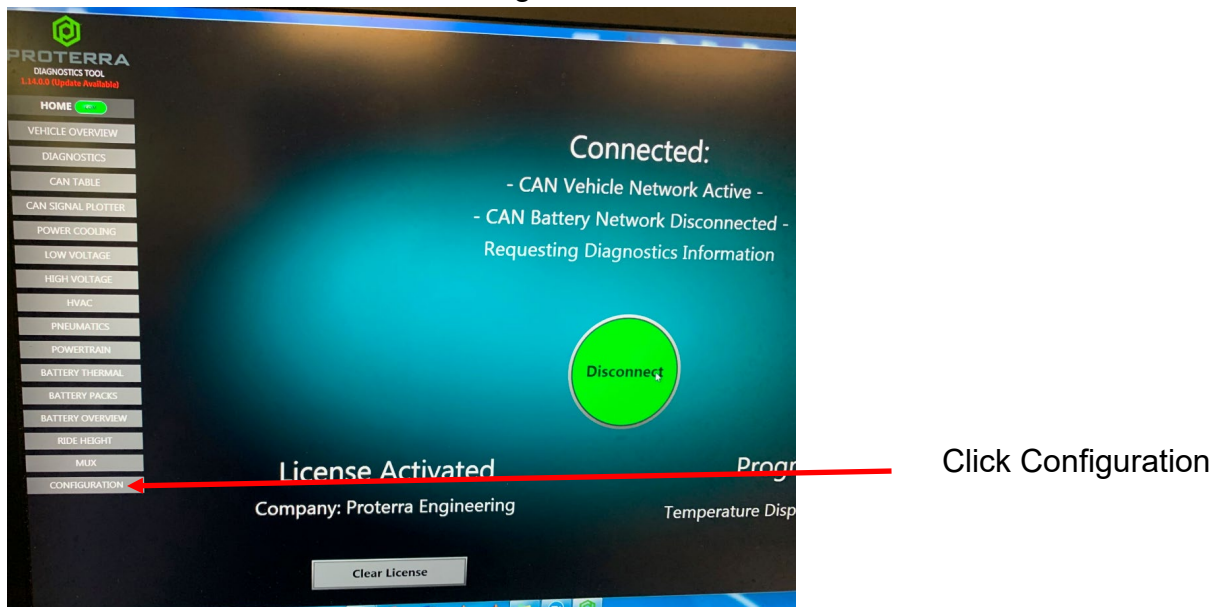
10. When the software update begins, the following screens will be displayed.



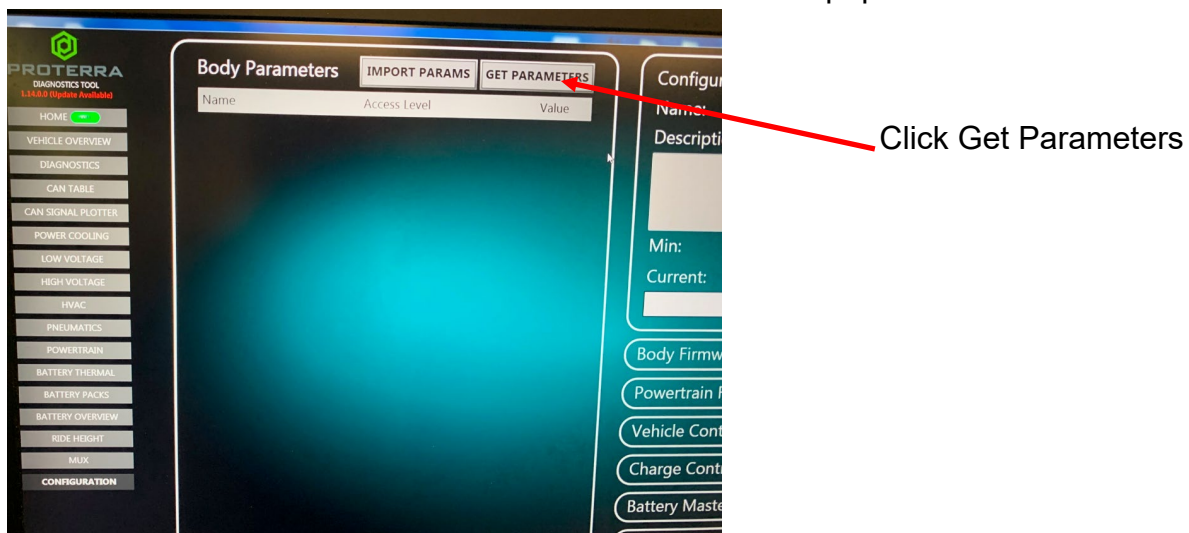
11. The software update may take several minutes to complete. When the update is complete the following will be displayed. Click the “OK” button to complete the update process.



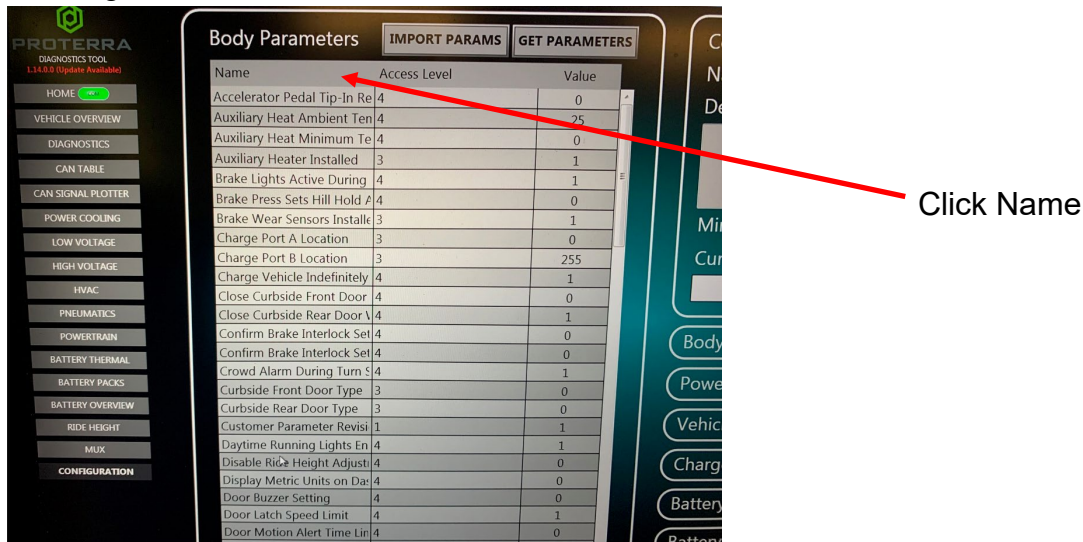
12. On the main screen, click the “Configuration” Button.



13. The following screen will appear. Click on the “Get Parameters” button to download information for the vehicle. Allow a few seconds for the information to populate the screen.

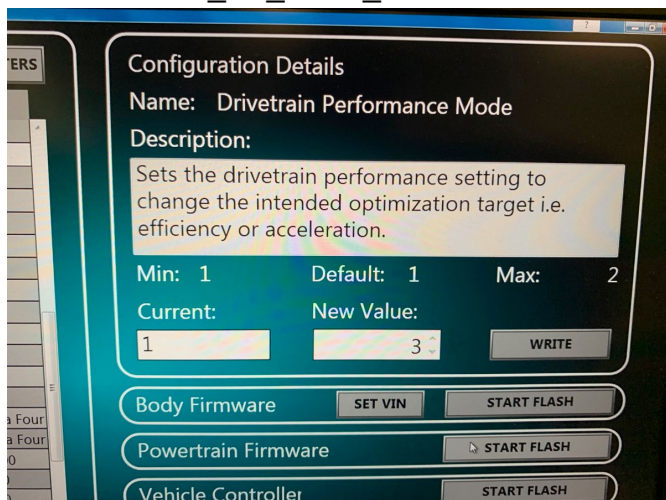


14. Once the screen has populated, sort the values alphabetically by clicking on the “Name” heading on the list.



15. Scroll through the list to find the “EP\_usi\_ZR32\_PerformanceMode\_x”. Click on the name of this parameter. See the “Proterra Powertrain Configuration Overview” on page 13 of this document for a description of this parameter.

16. A screen similar to the following appears. The difference is the parameter name. The name should be “EP\_usi\_ZR32\_PerformanceMode”.



17. Enter a 0 in the “New Value” box and hit the “Write Button”.

18. Scroll through the parameter list to find the “EP\_usi\_ZR32\_AllowedRNDLConfiguration\_xx” EEPROM value. See the “Proterra Powertrain Configuration Overview” on page 13 of this document for a description of this parameter.

19. Update the “EP\_usi\_ZR32\_AllowedRNDLConfiguration\_xx” value to 3.

20. The software update is now complete.

21. Disconnect the cable from the OBD-II port.

22. Close the Streetside wheel well box

23. Return the bus to service.

# PROTERRA POWERTRAIN CONFIGURATION OVERVIEW



## 1. Objective

To describe the different acceleration performance modes and regenerative braking configurations for the Proterra 800V bus platform ProDrive and DuoPower powertrain. To provide an understanding of how these configuration options impact range and energy economy.

## 2. Discussion

The Proterra powertrain system comes with the ability to configure the vehicle acceleration and deceleration drive feel to meet the customers' needs. These settings can be changed through the Proterra diagnostic tool when connected to a vehicle. There are two main drive feel settings:

- **Performance Mode:** This mode will change the maximum allowed vehicle acceleration rate
- **Regenerative Braking Configuration:** This selection will adjust the aggressiveness of regenerative braking when not accelerating (drivetrain-based braking)

### 2.1 Performance Mode

Proterra offers 3 distinct acceleration performance modes to tailor maximum vehicle acceleration to the customers' requirements. The three modes are called: Eco, Nominal and Max performance. These modes can be configured through the Proterra diagnostic tool variable **EP\_usi\_ZR32\_PerformanceMode\_x** (ECO= 0, Nominal= 1, Max= 2). The driver cannot change these modes real time through a button or switch.

Table 1 below shows the maximum achievable acceleration for each performance mode under peak motor conditions (no thermal derates). Proterra utilizes different acceleration limits to vary the performance of the vehicle. These acceleration limits will modulate torque to the drivetrain by monitoring the actual acceleration rate. If the acceleration rate of the vehicle approaches the limit, the traction inverter will reduce torque to ensure the limit is adhered to.

Acceleration limits primarily influence the vehicle speed below 30 MPH. Above 30 MPH, the vehicle speed is dictated by the power capability of the drivetrain. It is important to note that regardless of the performance mode, the powertrain will allow full power under scenarios where the acceleration limit is not being achieved. This is most critical under hill climb conditions. Therefore, the acceleration limit and performance mode will not impact vehicle gradeability performance.

Proterra recommends using the ECO Performance Mode (**EP\_usi\_ZR32\_PerformanceMode\_x = 0**) to maximize the efficiency of the vehicle.

Speed	APTA Whitebook	Eco Mode ProDrive	Eco Mode DP	Normal Mode ProDrive	Normal Mode DP	Max Performance Mode ProDrive	Max Performance Mode DP
(MPH)	time (s)	time (s)	time (s)	time (s)	time (s)	time (s)	time (s)
0	0	0	0	0	0	0	0
10	5	4.3	3.8	3.6	3.4	3.2	2.8
20	10	8.5	8.3	7.1	6.9	6.2	5.5
30	18	13.7	12.9	12.5	10.7	11.6	8.5
40	30	26.2	19.3	24.4	16.8	23.3	14.3
50	60	38.8	24.3	36.7	21.6	35.8	19.0
60	-	54.8	30.6	52.5	28.0	52.0	25.1

Table 1: Vehicle acceleration times for each performance mode, 0% grade, seated load weight

# PROTERRA POWERTRAIN CONFIGURATION OVERVIEW

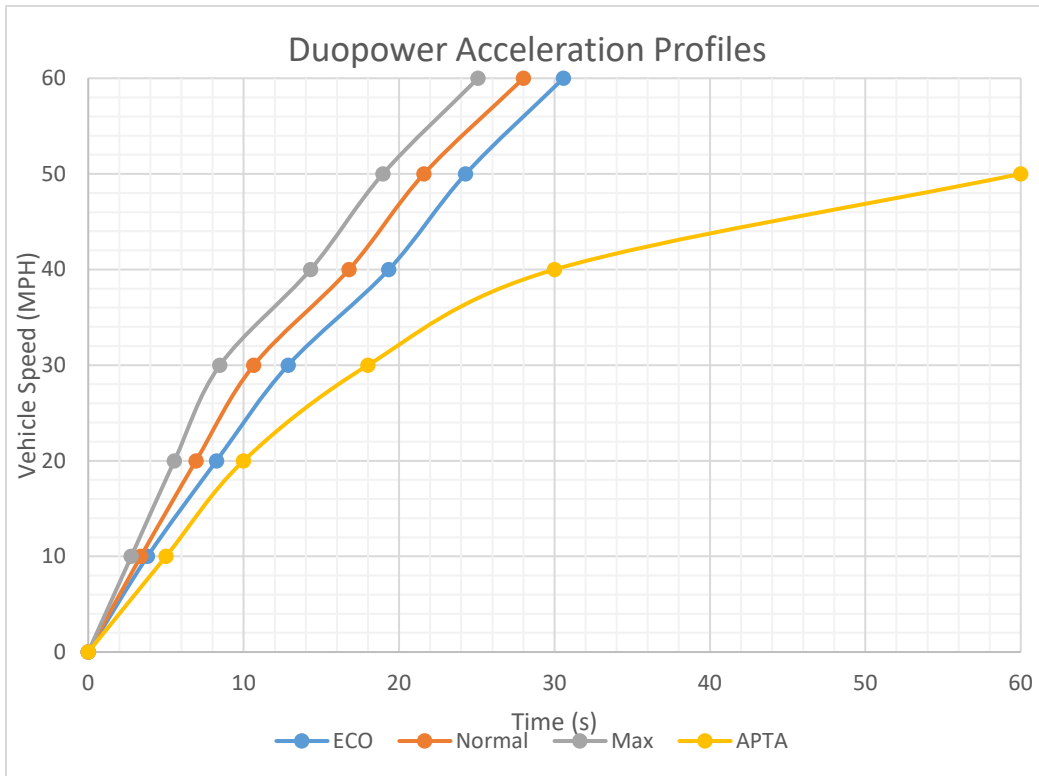


Figure 1: Vehicle acceleration chart for each Duopower performance mode, 0% grade, seated load weight

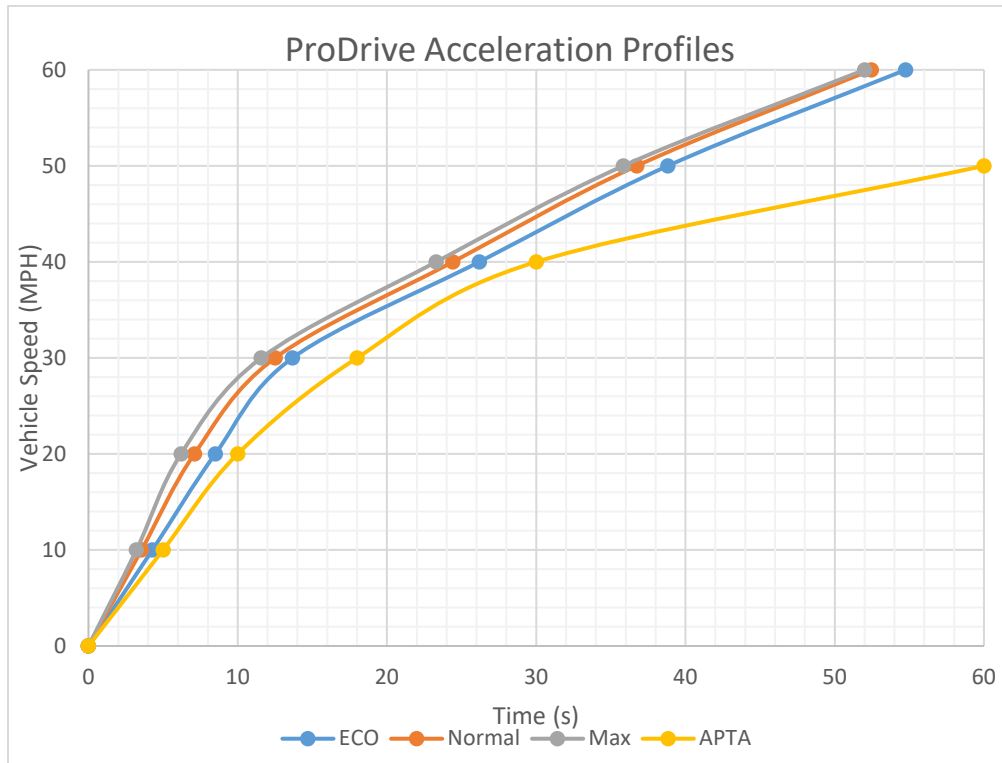


Figure 2: E2 vehicle acceleration chart for each ProDrive performance mode, 0% grade, seated load weight

## 2.2 Regenerative Braking Options with Gear Selector

Proterra offers two distinct driver selectable regenerative braking options through the gear selector module located in the driver's area. These levels will predominantly affect the amount of regenerative braking torque during a coasting scenario (no brake or accelerator pedal application).



Figure 2: Gear selector layout with D and L buttons

# PROTERRA POWERTRAIN CONFIGURATION OVERVIEW



- While in D (Drive): the vehicle will have a nominal amount of regenerative torque application while coasting. As the brake pedal is applied, regenerative torque will increase proportionally with the pedal to smoothly decelerate the vehicle. Friction brakes will start to add additional braking force in coordination with the regenerative torque of the drivetrain.
- While in L (Low): the vehicle will have a more aggressive level of regenerative torque application while coasting compared to D (drive mode). It will allow the vehicle to decelerate at a faster rate without application of the brake pedal. Similar to D, as the brake pedal is applied, regenerative torque will increase proportionally with the pedal to smoothly decelerate the vehicle. Additionally, friction brakes will start to add braking force in coordination with the regenerative torque of the drivetrain.

## 2.3 Regenerative Braking Configuration

Proterra also offers the ability to configure the regenerative brake level and selection options through the diagnostic tool variable **EP\_usi\_ZR32\_AllowedRNDLConfiguration\_xx**. The driver cannot change these modes real time through a button or switch. This configuration setting will alter what the driver is able to select at the gear selector.

At a high level, this EEPROM setting allows different combinations of 3 distinct regen levels. It also enables the ability to “lock out” a driver selectable option. Meaning, regardless if the driver pushes the D or L push button on the gear selector, he/she will only get a single regen braking level. This enables the customer to better control how the vehicle is operated in the field.

Proterra recommends using the most aggressive regen level (**EP\_usi\_ZR32\_AllowedRNDLConfiguration\_xx = 3**) to maximize the efficiency of the vehicle.

EEPROM Value	Drive (D)	Low (L)	Notes
0	Moderate	Heavy	Driver selectable regen levels, moderate DRIVE regen and aggressive LOW regen.
1	Minimal	Disabled	Driver selectable regen level disabled, minimal regenerative braking.
2	Moderate	Disabled	Driver selectable regen level disabled, moderate regenerative braking.
3	Heavy	Disabled	Driver selectable regen level disabled, most aggressive regenerative braking.
9	Minimal	Moderate	Driver selectable regen levels, least amount of regenerative braking options.
13	Minimal	Heavy	Driver selectable regen levels, minimal DRIVE regen and aggressive LOW regen.
14	Moderate	Heavy	Driver selectable regen levels, moderate DRIVE regen and aggressive LOW regen. This is the same config as EEPROM 0

Table 2: Regenerative Braking Configuration EEPROM Settings

# PROTERRA POWERTRAIN CONFIGURATION OVERVIEW



## 2.4 Impact on Range and Vehicle Efficiency

It is difficult to simulate how the vehicle efficiency and range will be impacted by the varying performance modes and regenerative braking configurations. However, through real world tests we have found a few key themes:

1. **MORE aggressive acceleration yields LOWER vehicle efficiency and range**- higher acceleration rates lead to higher vehicle speeds and road loads. This ultimately reduces vehicle efficiency and range. Proterra has observed efficiency impacts up to 10% based on different acceleration rates in real world operation.
2. **MORE aggressive regenerative braking yields HIGHER vehicle efficiency and range**- for a transit vehicle with lots of stop and go driving and lower average speeds, maximizing regenerative braking leads to higher efficiency. Proterra has observed efficiency impacts up to 7% based on different regenerative braking levels in real world operation.

### Powertrain related items that will directionally improve vehicle efficiency and range:

- Lower average vehicle speeds
- Lower vehicle acceleration
  - o Proterra's acceleration control algorithm helps in this category. It minimizes a "heavy footed" driver's influence on range by only allowing the prescribed acceleration defined in Table 1. This also improves the consistency of the vehicle acceleration across load conditions.
  - o Setting the Performance Mode variable **EP\_usi\_ZR32\_PerformanceMode\_x** to **ECO "0"** mode will **maximize vehicle range and efficiency**.
- Gradual braking
  - o It is important to minimize the use of pneumatic friction brakes to improve range and efficiency. This method to slow down the vehicle is wasted energy that turns into heat.
  - o Proterra's more aggressive regen options will improve efficiency under low speed driving by reducing the need to apply the brake pedal. Therefore, a larger percentage of energy can be recaptured by the battery system as regenerative braking operates.
  - o Setting the Regeneration Configuration variable **EP\_usi\_ZR32\_AllowedRNDLConfiguration\_xx** to **"3"** will **maximize vehicle range and efficiency**.

Other benefits to consider:

- "Low mode" can be used on steep downhill descents to emulate a driveline retarder in a conventional vehicle. This will improve brake pad life.
- "Drive mode" does have its advantages that should be considered:
  - o There may be ergonomic benefits to the driver's right foot. Less coasting regen will require less accelerator input to achieve similar torque output while maintaining the same speed. This may be more desirable on higher speed routes.
  - o Less coasting regen may be more desirable under slippery scenarios such as snow or ice. Regenerative braking can induce wheel slip events in these conditions and Drive Mode may reduce the probability of wheel slip from occurring.
  - o Certain drivers may prefer a more conventional feeling bus based on what they are used to. Drive Mode gives them that option.

# PROTERRA POWERTRAIN CONFIGURATION OVERVIEW



## 2.5 Software and Hardware Compatibility

### DuoPower Drivetrain

- The Performance Mode and Regenerative Braking Configuration features defined above are fully released and validated for DuoPower software v1.3.0 (SC-20-115) and body software v6.3.0 (SC-20-91).
  - o Proterra recommends using the ECO Performance Mode (**EP\_usi\_ZR32\_PerformanceMode\_x = 0**) to maximize the efficiency of the vehicle.
  - o Proterra recommends using the most aggressive regen level (**EP\_usi\_ZR32\_AllowedRNDLConfiguration\_xx = 3**) to maximize the efficiency of the vehicle.

### 800V ProDrive Drivetrain

- The Performance Mode feature defined above is fully released and validated for ProDrive software v1.1.1 (SC-20-95) and body software v6.3.0 (SC-20-91).
  - o Proterra recommends using the ECO Performance Mode (**EP\_usi\_ZR32\_PerformanceMode\_x = 0**) to maximize the efficiency of the vehicle.
- The Regenerative Braking Configuration feature is partially implemented with ProDrive software v1.1.1 (SC-20-95) and body software v6.3.0 (SC-20-91). **NOTE:** Only EEPROM options 0,1 and 2 are available currently.
  - o Proterra recommends using the most aggressive regen level (available with this software release) (**EP\_usi\_ZR32\_AllowedRNDLConfiguration\_xx = 2**) to maximize the efficiency of the vehicle.
  - o A future ProDrive software release will enable more regenerative braking configuration options.