Proterra

Zero-Emission Battery Electric Bus Charges at On-Route Bus Stations

speedgoat
real-time simulation and testing

PROTERRA

Powerful Hardware-in-the-loop (HIL) test benches enable Proterra to rapidly test and continuously improve next generation vehicle management, powertrain, and energy storage controls technology

Proterra, with its headquarters and manufacturing in Greenville, South Carolina, USA, is a world leader in the design and manufacture of zero-emission vehicles, that enable bus fleet operators to reduce operating costs and deliver clean, quiet transportation with zero tailpipe emissions.

Battery electric bus

Proterra's second generation bus is not only the world's most efficient battery electric bus, it can be charged at a bus stop during the time it takes passengers to alight and board, and so can operate 24/7 without additional stops for refueling.

On-route charging

The bus's advanced battery system, featuring on-route, fast charging, consists of 8 packs, each with an individual pack level controller. A charge of less than 10 minutes provides the vehicle with

The new hardware-in-the-loop test bench

a range of around 30-40miles (50-65km).

Controllers

Key for the bus are the master vehicle, powertrain, and energy storage controllers.

The master vehicle controller performs controlling functions for the many devices found on a passenger bus, such as doors, exterior and interior lights, power steering, and air compressor. It also performs high level supervisory control and diagnostics.

The energy storage controller constantly monitors aspects of the battery system such as temperatures, currents and voltages to determine the allowable discharge and charge rates for driving and charging operations.

The powertrain performance is monitored and controlled by the powertrain controller which ensures it's efficient operation at different driving conditions.

Hardware-in-the-loop

Proterra decided to leverage a hardware-in-the-loop (HIL) development approach to aid the testing and development of the control systems for the new transit bus.

HIL allows control systems to be thoroughly tested in the lab by simulating vehicle

components including sensors and communications that would normally provide data from the real world. Simulation allows complete control of the inputs to the control system, and so allows tests to be performed rapidly and easily.

Proterra decided to use Speedgoat solutions for HIL, as its systems are expressly designed for use with Simulink.

Test bench

Proterra developed a real-time application with Simulink, to run all the major vehicle components, the vehicle's extensive CAN protocol networks, and all the digital and analog I/O, including temperatures, pressures and speeds. For example, pulse signals were used to simulate the speed of the fans found in the cooling subsystems of the bus, and to simulate feedback related to the status of the vehicle components such as doors, low voltage contactors, and the gearbox.

To run the real-time application, a Speedgoat Performance real-time target machine was used, providing all required I/O and communications protocols.

The target machine was chosen for its powerful Intel CPU, its flexibility, and its ability to support a wide range of I/O connectivity.

The project was a great success with Proterra praising the seamless integration of Speedgoat and MathWorks tools.

Speedgoat's value contribution

"I feel that Speedgoat has certainly developed a plug-and-play real-time platform for Simulink. For us, that translates into more time testing our control systems and less time developing a HIL bench" said Mr. Reyes.

Mr. Reyes also commented:

"The technical support is outstanding. Whenever necessary, Speedgoat and MathWorks have worked together to resolve any questions or issues I encountered during the development of our project.
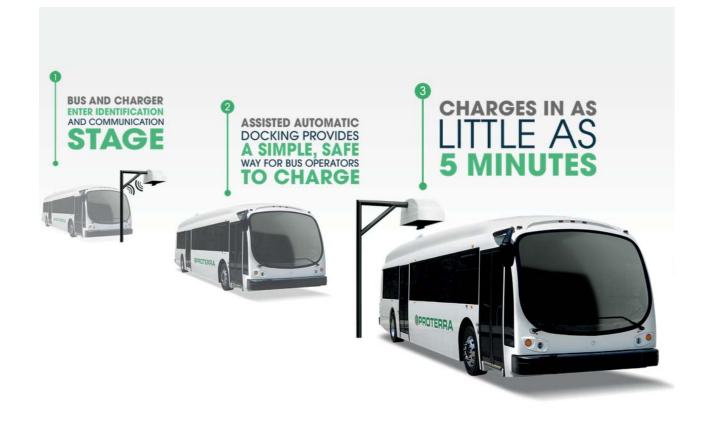
The documentation and self-help website are excellent.

Top quality hardware is used in the Performance real-time target machine.

As our project has expanded and increased in complexity, I have always found the solution with Speedgoat."

Joaquin Reyes, Controls Engineer, Proterra

1. **BUS AND CHARGER ENTER IDENTIFICATION AND COMMUNICATION STAGE**

2. **ASSISTED AUTOMATIC DOCKING PROVIDES A SIMPLE, SAFE WAY FOR BUS OPERATORS TO CHARGE**

3. **CHARGES IN AS LITTLE AS 5 MINUTES**

Advanced on-route charging - the specially designed lithium titanate batteries can charge in as little as 5 minutes and can operate 24/7 without conventional refueling

Proterra

Greenville, South Carolina

www.proterra.com

Speedgoat products used

- Performance real-time target machine
- I/O expansion chassis
- IO102 analog I/O module
- IO110 analog I/O module
- IO204 high voltage digital I/O module
- IO205 high voltage digital I/O module
- IO206 high voltage digital I/O module
- IO311 FPGA I/O module with PWM generation and capture
- IO601 CAN I/O module
- IO921 programmable resistor I/O module

MathWorks software used

- MATLAB®
- Simulink®
- MATLAB Coder™
- Simulink Coder™
- Simulink Real-Time™

Learn more

www.speedgoat.ch/userstories

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