# Hitting a Moving Target - Designing a HILS Test Rig for an Electric Vehicle Startup Company

Imagine the challenge. You are working for an electric vehicle (EV) startup company, designing the Hardware-in-the-Loop Simulation (HILS) test system. Everything is new – the hardware, the software, the tools, the testers and the test code. Yet, the system must be as accurate as possible in order to correctly simulate the operating environment. You're also working on the electronic control unit (ECU), which houses the EV batteries. In order to test them thoroughly, they will need to be stressed beyond their normal operating range. Since the test environment can be quite dangerous – you will need a blast-proof bunker.

To summarize, it's a very dynamic situation with a high degree of risk. Then, of course, because they are a startup, there is a very aggressive schedule without the established product roadmap, which would enable you to predict test system requirements accurately for two to three years ahead. You've got maybe six months' visibility. You're going to need a very flexible and scalable system.

## Hardware in the Loop Simulation for Automotive ECU Systems

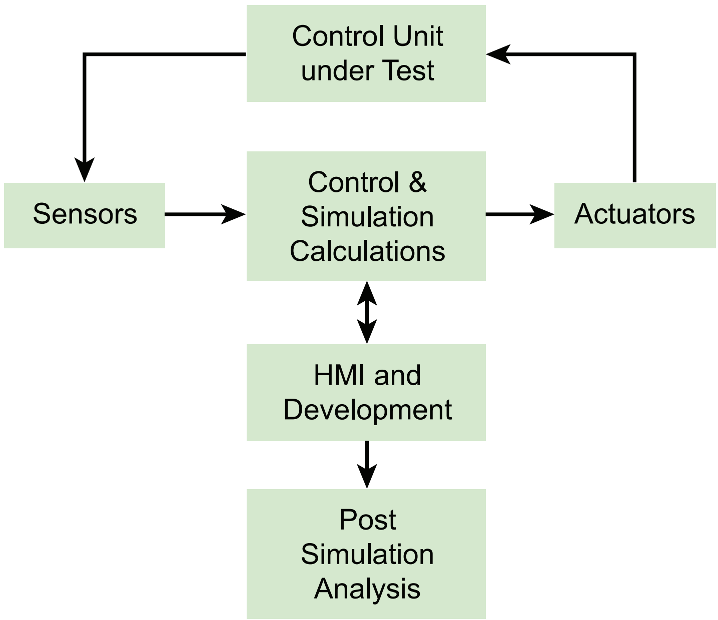
ECUs are at the heart of many products. During development, HILS is typically employed to test the operation of the ECU in a simulated real-world environment in which the ECU will operate. Instrumentation is used to simulate an ECU's sensor inputs and capture and verify the ECU control outputs. Safety-critical controllers will usually require certification, where faults including short and open circuits are introduced, and the ECU's response is analyzed to check that it is performing in a predictable and, above all, safe manner. Automated fault insertion systems allow verification tests to be run efficiently in a controlled and repeatable way.

The automotive environment can often be very hostile, especially for sensors, with wide ranges of temperature commonly experienced. Failures can occur due to corrosion, aging, damage or even faulty installation. Because of all the features and options available in vehicles, especially as more electronic systems are being introduced for ADAS systems – ultimately autonomous driving – infotainment, in-car AI and security, the ECUs are becoming very complex, so the accuracy of HILS is essential for a successful launch.

With EVs comes a new challenge. In a conventional vehicle, the battery is quite simple. In an EV, the battery dominates, so the ECU that manages the battery must be highly accurate, efficient and guaranteed reliable to ensure safe operation.

## Software Testing a Battery ECU in an Electric Vehicle Startup Company

Pickering Interfaces provides products and services to streamline the design, deployment and sustainment of high-performance electronic test and verification systems. The company was approached by a team designing the software test systems for battery ECUs in an EV startup. Both a HIL test system and a benchtop tester were required.




**Example of Hardware-in-theLoop-Simulation**

The software test team faced three challenges. First, it found itself in a very dynamic and changing situation. As a startup addressing a new market, the product range was still evolving as new requirements emerged. This meant that long-term test strategies with common test elements were difficult to plan and implement. Second, everything was new. The ECU software, hardware and sensors were new. Both the hardware and software needed debugging, and sometimes it was not obvious whether the issue was caused by a hardware fault or in the software. The battery configuration was also new.

Indeed, the test team itself – although comprising highly experienced personnel – was also new. Finally, the test environment was potentially dangerous. To ensure operational safety, the batteries must be tested well above their specified rating. High currents up to 50 A and high voltages must be employed. Therefore, lots of redundancy was necessary.

Against this background, the team was constantly battling to ensure that the test system was functionally safe, accurate and repeatable, and able to respond to dynamic hardware and software developments. In their words, it was "a monumental challenge to wring out all the pieces simultaneously while adhering to an aggressive schedule".

Therefore, the software test platform needed to be expandable and very flexible. The decision to use instrumentation based on industry-standard PXI and LXI formats was obvious. Still, the EV startup also decided to use both a fully functional HILS system and flexible benchtop equipment in its software test strategy.

HILS systems must simulate the environment that the system under test will operate. This can be achieved using models or by physical means. Accuracy and repeatability are vital. Models can be very space- and cost-effective, but accuracy can suffer. With batteries, it is critical to control the temperature to prevent thermal runaway. Batteries for EVs can easily employ over 100 thermistors. The EV test development team preferred to use programmable resistors as a physical representation of the thermistors since their behavior is much closer to that of a thermistor (which is, of course, a type of resistor). The programmable resistors will also give the full range of characteristics of the actual sensor, including variations with temperature – described by the EV company as the 'thermal isotope.' However, with over 100 sensors to simulate, it is necessary to select programmable resistor cards with as many channels as possible to avoid making large test systems. The customer commented that the test system "is more complex than the actual system to be able to simulate and test for all possible eventualities".

Fault insertion is another consideration; for example, how do you replicate and respond to a broken wire? If driving a large relay, in a worst-case scenario, currents as high as 50 A might be in circulation – basically a welder – so all the circuitry must be able to handle 50 A and respond in a specific time and shut off effectively.

## Pickering Solutions

The HIL Test System Team Lead at the startup was a long-time user of Pickering products from his previous employment. Because the team's existing HILS systems were not flexible enough to meet its needs for new test ranges and capabilities, they decided to approach Pickering to overcome the limitations. Pickering worked with the team to develop a roadmap for a HILS system that was more appropriate for their requirements.

A complete physical HILS system based around the following Pickering products:

- PXI battery cell simulator (model 41-752)
- PXI programmable resistor modules (a customized version of their model 40-295)
- PXI fault insertion switching (model 40-190B)
- PXI high-density multiplexers (models 40-614C & 40-615A)
- PXI 14-slot chassis (model 40-914)

The HILS system was designed for fully automated operation, performing complete physical function tests overnight unattended. For more specific, granular test, the EV company also specified benchtop systems based around similar products housed in Pickering's 2-slot LXI/USB chassis (model 60-104-001). Whereas with the complete HILS system, the emphasis was on the performance, scalability, and flexibility of the Pickering solutions, small size was the key advantage for the benchtop tester.

In addition to these benefits, the EV test system development team commented that Pickering's long history of delivering high-quality products that are easy to use and easy to program were significant reasons for choosing Pickering. "With all the changes that we were dealing with, it was nice to have something to rely on – that I don't have to worry about," said Pickering's customer.

## About Pickering Interfaces

Pickering Interfaces designs and manufactures modular signal switching and simulation for use in electronic test and verification. We offer the largest range of switching and simulation products in the industry for PXI, LXI, USB and PCI applications. To support these products, we also provide cable and connector solutions, diagnostic test tools, along with our application software and software drivers created by our in-house software team.

Pickering's products are specified in test systems installed throughout the world and have a reputation for providing excellent reliability and value. Pickering Interfaces operates globally with direct operations in the US, UK, Germany, Sweden, France, Czech Republic and China, together with additional representation in countries throughout the Americas, Europe and Asia. We currently serve all electronics industries including, automotive, aerospace & defense, energy, industrial, communications, medical and semiconductor. For more information on signal switching and simulation products or sales contacts please visit: pickeringtest.com.

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**Direct Sales & Support Offices**

**Pickering Interfaces Inc., USA**
Tel: +1 781-897-1710 | e-mail: ussales@pickeringtest.com

**Pickering Interfaces Ltd., UK**
Tel: +44 (0)1255-687900 | e-mail: sales@pickeringtest.com

**Pickering Interfaces Sarl, France**
Tel: +33 9 72 58 77 00 | e-mail: frsales@pickeringtest.com

**Pickering Interfaces GmbH, Germany**
Tel: +49 89 125 953 160 | e-mail: desales@pickeringtest.com

**Pickering Interfaces AB, Sweden**
Tel: +46 340-69 06 69 | e-mail: ndsales@pickeringtest.com

**Pickering Interfaces s.r.o., Czech Republic**
Tel: +420 558 987 613 | e-mail: desales@pickeringtest.com

**Pickering Interfaces, China**
Tel: +86 4008-799-765 | e-mail: chinasales@pickeringtest.com

Local Sales Representative/Agents in Australia, Belgium, Canada, China, India, Indonesia, Israel, Italy, Japan, Malaysia, Netherlands, New Zealand, Philippines, Singapore, South Korea, Spain, Taiwan, Thailand, Vietnam and throughout the North America.

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