



Taking Control

Subaru Forester

One of the greatest challenges for electric and hybrid vehicle designers is creating accurate control systems that balance safety, performance and energy efficiency. For nearly a decade, Subaru has relied on ANSYS SCADE solutions to develop the software code that underlies the electronic control units (ECUs) for its electric car program. By leveraging SCADE, Subaru engineers can quickly and accurately generate the mission-critical code that keeps electric vehicles running safely and smoothly, no matter how complex their technology architecture.

By ANSYS Advantage Staff

For the past decade, Subaru Corporation has been at the forefront of hybrid and electric vehicle design, beginning with its hybrid engine design for the Subaru XV in 2013 and continuing with its fifth-generation Forester SUV introduced in 2018, supported by a second-generation hybrid engine called the e-BOXER.

To answer consumer needs and maintain the company's industry leadership, Subaru engineers have included more and more advanced technologies with every new e-vehicle launch. Critical systems like propulsion, acceleration and braking are now complemented by infotainment systems, customized heating and cooling options, and other electronics that add to the driving experience.

Bringing all these sophisticated systems together, safely and seamlessly, means establishing a flawless system of controls. All components must integrate perfectly with one another, and mission-critical functions that could lead to a system failure, such as steering, must be protected.

Maintaining and managing all these systems is the job of the electronic control unit (ECU) that lies at the heart of every hybrid and electric vehicle. Supported by millions of lines of underlying embedded software code — and subject to strict regulatory oversight — the ECU is one of the most crucial elements of any electric car.

Yuji Kawakami, senior engineer in Subaru's electronics engineering department

While Subaru often partners with major auto parts manufacturers to co-develop vehicle components, the engineering team in Subaru's Tokyo-based electronics department



“While SCADE solutions save valuable time, they also support Subaru’s long-standing commitment to delivering high levels of product quality and passenger safety.”

assumes full responsibility for designing and verifying the ECU. Since 2008, these engineers have relied on SCADE solutions from ANSYS to model and generate the ECU’s embedded software code. SCADE has played an essential role in the fast, cost-effective and accurate creation of this code for each of Subaru’s hybrid-electric vehicles.

A MORE DIRECT ROUTE TO CODE GENERATION

The process of generating software code for the ECU begins by defining the control logic for bringing all the parts of the car’s electronics architecture together.

This set of logic-based rules ensures that all the car’s electronics are integrated safely and securely. It manages the system interactions, sends alerts when needed and can also shut down systems in an emergency. It controls vehicle dynamics, engine function, the vehicle’s energy consumption and the load management of the electric battery.

For the Forester e-BOXER, which features an innovative, horizontally opposed engine, the ECU delivers added intelligence that balances optimal driving conditions with high fuel efficiency. For example, the e-BOXER’s ECU is programmed to support smooth but firm acceleration via a motor assist function, without creating an energy drain on the battery. This

adds new complexity to the control logic and places additional demands on Subaru’s engineers to ensure the ECU’s accuracy and tight control.

To create the control logic needed to drive the ECU, Subaru engineers use MATLAB/Simulink, a common industry practice. However, according to Yuji Kawakami, senior engineer in Subaru’s electronics engineering department in Tokyo, the Subaru team continues to apply specialized technology to



Subaru e-BOXER

produce a systems architecture and underlying software code. While many other automotive engineering teams rely on manual methods to accomplish these tasks, Kawakami leads Subaru’s effort to significantly accelerate this process by applying SCADE software.

“First, Subaru engineers convert the control logic into a SCADE model of the overall system architecture, using SCADE Suite Simulink Gateway,” said Kawakami. “Then our engineers apply SCADE Suite KCG Code Generator to create implementation code based on this model.”

Kawakami noted that this development flow has remained the same at Subaru for nearly a decade, beginning with the ECU for the Subaru XV and continuing through the more complex ECU to support the e-BOXER. A key benefit of this development flow is that many steps — from Simulink to model creation to code generation — are automated, requiring almost no manual intervention.

“In generating control software code for Subaru’s first hybrid vehicle, the Subaru

XV, about 80% of the

development work was automated,”

Kawakami stated.

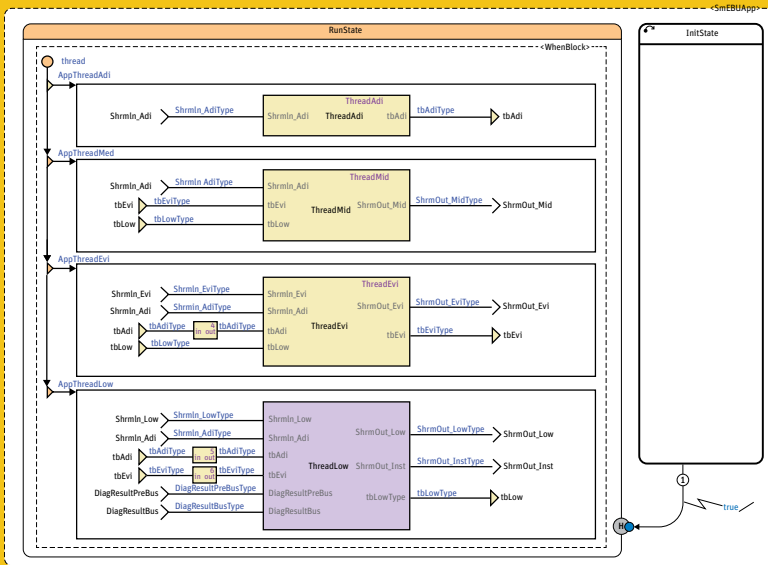
“As Subaru’s engineering team improved its internal processes by using ANSYS SCADE, the amount of automation

increased to 95% for the code underlying the e-BOXER.”

Today, it only takes Subaru engineers half a day to implement a model for an ECU once the Simulink control logic has been defined. This enables Subaru’s developers to modify the ECU’s logic and architecture much more frequently and easily as they explore continuing design innovations.

ENSURING OUTSTANDING SAFETY, PRODUCT QUALITY AND COMPLIANCE

Subaru has a long-standing commitment to delivering high levels of product quality and passenger safety. While SCADE solutions save valuable time, they also support that commitment by



Threads management example

delivering extreme accuracy and control for software engineers. Unlike generic tools, SCADE is a specialized tool for developing embedded software code. Its model-based environment and tight scripting language eliminate the potential for human error as it translates the control logic for the ECU.

“In Subaru’s experience, SCADE generates such a highly reliable code that a manual review is no longer required, resulting in a great reduction of tasks.”

Because the SCADE Suite KCG Code Generator meets automotive industry standards such as ISO 26262 at the highest levels of safety (ASIL D in that case), the resulting code is automatically in compliance with strict regulations — dramatically reducing the time, effort and documentation required for final code verification. SCADE is a key tool not only for meeting regulatory standards, but for supporting Subaru’s commitment to passenger safety.

Kawakami pointed out, “In Subaru’s experience, SCADE generates such a highly reliable code that a manual review is no longer required, resulting in a great reduction of tasks. The embedded software code for the ECU in an automobile hybrid system is complicated and numerically large, especially for an intelligent hybrid

engine system such as e-BOXER. It typically takes significant time and effort to manually check this code, so eliminating this step has significantly improved productivity and reduced costs for the Subaru development team.”

In addition, the use of SCADE facilitates a closed-loop software engineering process. In the event

that the overall ECU control logic is modified in Simulink at a later date by Subaru engineers, SCADE solutions automatically and universally reflect these changes in the system model and embedded software code, eliminating costly rework and manual updates.

WINNING THE RACE VIA ACCELERATED MARKET LAUNCHES

“When Subaru engineers first started using ANSYS SCADE solutions, we were impressed by the initial improvements in speed and efficiency,” stated Kawakami. “Over time, these improvements have only been amplified as the product development team has increased its ability to leverage SCADE’s capacity for task automation.

“In developing the ECU for the e-BOXER, most steps were successfully automated, and the process included almost no human intervention,” he continued. “Even non-dedicated engineers in other departments are able to convert control logic from Simulink to SCADE and generate accurate software code.”

In the race to launch new hybrid and electric vehicle models, SCADE has emerged as a valuable strategic tool for Subaru over the past decade, supporting the automaker’s commitment to uncompromising safety and quality. The time saved during the end-to-end development of the ECU — without sacrificing the accuracy of its control software — has been crucial to Subaru’s ability to introduce innovative new technologies like the e-BOXER quickly, seizing a competitive advantage in an increasingly crowded industry segment. ▲



Functional Safety Analysis and Support for ISO 26262 for Automotive Applications ansys.com/iso26262