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Hardware-In-the-Loop Validation of Vehicle Control Loops

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Automobiles have already transitioned from a mechanical beast to an electrical/electronic beast. On the other hand, what has also already happened, but most people are not aware of, is the fact that they have transitioned to a software beast as well. Automobiles contain several CPUs, each one with a different purpose, running really complex programs. Validation of these programs, and of the systems they form, is very critical, as a bug in one of them may result in material and human loss [1,2]. This paper addresses the problem of verifying one of these softwares, i.e., the one running on the Engine Control Unit (ECU).

The control algorithms running on the ECU (which supervises energy and torque management) cannot be tested on the vehicle until it is mature enough, because problems in the algorithm may cause great material loss (if not human loss). It is also not easy to create all required test scenarios with the vehicle involved. That is why a real-time computer called Hardware-In-the-Loop (HIL) [3] is used to emulate the vehicle, while the actual ECU is used to run the control algorithms.

This work serves both as a crash course on HIL/ECU emulations and a case study. It is based on a Plug-in Electric Vehicle (PEV) [4]. We first implemented the controller (a basic PID algorithm) and the vehicle models in MATLAB/Simulink. Then, we ported the controller to OpenECU (which is also the controller of choice in the actual vehicle) and then ported the vehicle models to two different HILs, namely, OpalRT and ETAS. We compared and contrasted the two HIL implementations, and hence, allow our audience to see what the main idea is in HIL based validation and what is specific to a particular HIL platform.

Keywords: Automotive Software Validation, HIL, ECU, PEV.

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