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Tutorial Title:

Model-Based Control Design and Testing with Embedded Code Generation Using the PLECS Toolchain

Organizer:

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Abstract:

The development of a power electronic system is a multidisciplinary endeavor. It includes not only the power stage design, but also the development of the controls, which are often implemented on a microcontroller (MCU). Yet few engineers are equally skilled in hardware and software design. For example, electrical engineers are usually not professional software developers by education, however, they are often assigned the task of programming embedded MCUs at work due to their knowledge of how to control a power converter and the full system requirements. Further, they have a good understanding of the MCU's on-chip peripherals such as PWM generators and ADCs.

Meanwhile, with today's short time-to-market pressures, there is little intrinsic motivation to write code that can be reused and maintained over a product's entire lifetime. As a result, the handwritten codebase often lacks modularity, clear structure and proper documentation. For these reasons, we should support electrical engineers in what they are good at, namely electronics and control design, and leave the software architecture and implementation either to experienced software developers or to a computer program that generates the code automatically. Of course, the latter option will only be desirable if it accelerates and simplifies the development process right from the start.

PLECS in conjunction with the PLECS Coder lets control engineers not only intuitively model and simulate controls for power electronics, but also easily implement them on selected MCUs. This automatic code generation workflow neither requires special software development skills nor in-depth knowledge about the MCU peripherals. The iterative development approach using a PLECS model allows a design to evolve from an initial concept to a robust implementation where the model serves both as the control algorithm's definition and documentation.

The advantages of this approach are numerous. Configuring and accessing the MCU's I/O peripherals is no longer the manual and error-prone task of setting individual bits in configuration registers. Further, the control system can be developed and verified against a plant model using offline software-in-the-loop (SIL) simulation of the generated code on the host computer. This allows the user to identify any discrepancies between the original model and its C code implementation, such as the discretization of time-continuous control blocks. Once the embedded code is on the target MCU, the user can test and debug it by observing real-time data in PLECS and interact such as by tuning setpoint parameters.

In this tutorial, participants are welcome to bring laptops for an interactive walkthrough of the PLECS code generation process. After minimal lecture material is provided for laying out the basic building blocks and GUI, attendees will build a simple closed-loop control model, generate code for it for an STM32 MCU test kit and verify its performance with an on-board power stage. Temporary PLECS licenses and MCU hardware will be distributed during the tutorial. Further, we will demonstrate practical applications including synchronous sampling for event-based execution of control tasks, multi-tasking environments for cascaded control structures, and the use of state machine charts for supervisory control purposes.

Bio:

Dr. Beat Arnet is an expert in the field of power electronics, with over 25 years experience in power converter design for automotive and renewable energy applications. He is General Manager for Plexim Inc where he applies his industry experience to oversee the development of the PLECS embedded code generation tools.

Before joining Plexim, Dr. Arnet led electric drive component development at Azure Dynamics (AZD) and oversaw the design of power electronics, electric machines, gearboxes and control software. Prior to AZD, he worked at TIAX, consulting for the automotive industry. There he developed hardware prototypes for active Li-Ion cell balancing and battery management, including high-frequency DC-DC converters. Before TIAX, Dr. Arnet managed the Control Electronics group at Solectria, contributing to developments in distributed generation (DG) and hybrid electric vehicle (HEV) drives.

Dr. Arnet holds a diploma in Electrical Engineering from the Swiss Federal Institute of Technology in Zurich and received his Electrical Engineering PhD from the Swiss Federal Institute of Technology in Lausanne. He is the principal inventor of 5 US patents and has authored and co-authored over 15 publications. He is a Senior Member of IEEE, and is a Member of both the Power Electronics and Industry Applications societies.