New Hardware-in-the-Loop Based Power Electronics Teaching Laboratory

"Typhoon HIL power electronics teaching laboratory provides engaging, hands-on, and intuitive learning environment which makes laboratory classes fun and effective for students while being in 100% safe environment"

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Introduction

Modern power electroncs applications require increasingly complex, fast, flexible and robust control systems, hence the performance requirements for embedded controllers is continuously increasing. The need for well-equipped, effective, versatile, flexible, and safe digital power education platforms and laboratories, to educate the next generation of power electronics engineers and researchers, is becoming criticaly important.

An innovative digital signal processor (DSP) based power electronics and motor drives hands-on teaching lab enables students to rapidly and efficiently learn to program DSP and configure the peripherals for real-time applications and control/manage the power digitally. The core of the platform is the *Typhoon HIL* ultra-high fidelity Hardware-in-The-Loop (HIL) system and associated real-time power electronics emulation tools empowering students to easily create re-configurable real-time power plant models which are controlled by the industrial-grade DSP controller hardware. This hybrid approach to hands-on teaching provides an engaging, user friendly, and completely safe environment for students to experiment with advanced energy conversion systems, develop industrial quality controllers for a spectrum of energy conversion applications for virtually any power level, ranging from watts (W) to megawatts (MW).

Challenge

For most of the today's power electronics practicing engineers solid knowledge of microcontroller or DSP is an imperative. However, learning the basics of such embedded systems is a grueling process due to the specialized architectures of the industrial grade embedded systems.

Another key challenge for a truly hands-on digital power control course is the design stage of a hardware setup which requires a solid background in mixed signal circuit design, power topologies, pcb layout design, EMI, protection, component selection etc. In addition, the complex mixed signal designs can easily be damaged by the students during the experiments where they are required to reconfigure hardware and probe various test points. Maintaining complicated hardware based lab systems is another issue for instructors. Furthermore, the laboratory experiments are strictly limited with the hardware, and it is not feasible to make experiments using different plants, topologies, components, digital signal processors and keep the lab content up to date. Indeed, for an effective and engaging hands-on course, the teaching lab setups should be as flexible as possible to enable students to work on the cutting-edge technologies.

Solution

An alternative way to address these issues and effectively teach all aspects of DSP based power electronics is to use a ultra-high fidelity power electronics real-time emulators directly interfaced with the real digital controller systems. In the HIL configuration, a DSP controller can't tell the difference whether it is controlling a real power stage or a real-time emulator due to the ultra-high fidelity of real-time emulation process. This approach allows students to design various power conversion systems such as motor drives, grid tied inverters, photovoltaic converters, dc-dc converters etc., and optimize the system parameters and control it safely without being exposed to the risk of electric shock or mechanical accidents while working with realistic and ultra-high fidelity environment.

Teaching Modules

Implemented teaching modules span a spectrum of applications: from wind turbine drives, photovoltaic converters, active filter all the way to motor control, hybrid/electric vehicle drives, and power supplies, as illustrated in figures below.

Students can adjust the level of technical detail and complexity, according to their needs, starting with a fully working closed loop converters, exploring the performance of the closed loop system, fault tolerance and generally get familiar with the application.

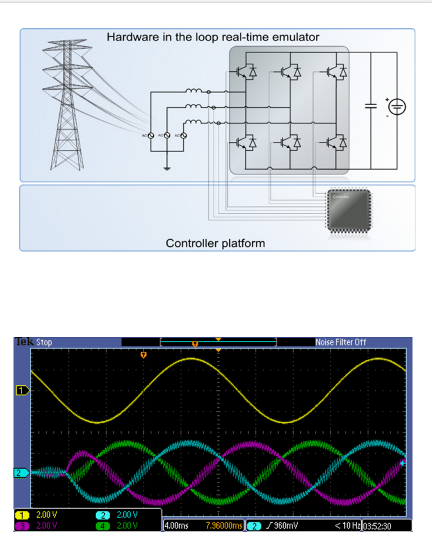
In the subsequent exercises students develop their control algorithms from ground up, usually starting with building their own modulators, closing current loops, developing and testing phase lock loops..., all the way towards the application software and protection schemes.

Conclusion

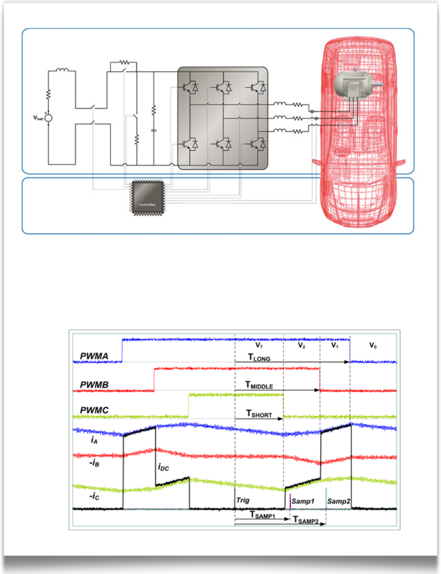
Effective digital power education platforms and laboratories are ever so important to train the next generation engineers and researchers.

Ultra-high fidelity Typhoon Hardware-in-the-Loop based power electronics teaching laboratory enables students to rapidly learn how to configure the peripherals of a DSP for real-time applications and control/manage power digitally.

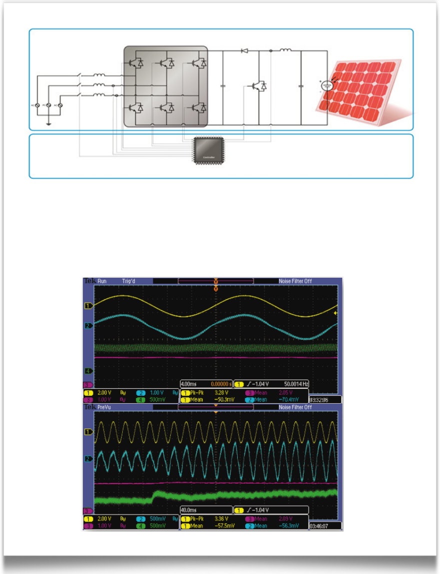
In order to ease the learning process, the combination of hardware in the loop system and digital signal processor has been used to teach the basics of digital power concept and the details of real time control. HIL real time emulator acts like an actual plant that is controlled using DSP platform enabling safer, easier and user friendly interactive platform.



Grid connected converter example.



Electric vehicle IM drive example.



PV inverter example.

The new Typhoon HIL based teaching laboratory at the University of Texas at Dallas.

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