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Written by: nicolas.cherix@imperix.ch
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PUBLIC DOCUMENT

INTERNSHIPS AND RESEARCH PROJECTS

Written by: Imperix ltd, Rte. des Ronquos 23, 1950 Sion, Switzerland
Addressed to: Any R&D-performing academic institution or industrial company

APPLIED PROJECTS IN POWER ELECTRONICS

CONTROL OF MODULAR MULTILEVEL CONVERTERS FOR VARIABLE-SPEED DRIVES

Motivations: Develop flagship control examples for complex multilevel converters.
Objectives: Design, implement and validate the control of an MMC when used within a variable-speed drive. The related challenge is linked to the necessary injection of medium-frequency components into the circulating currents, so that the physical size of submodule capacitors can be maintained within reasonable boundaries.
Skills: A strong background in automated control is recommended.

DIRECT (MATRIX) AC/AC FREQUENCY CONVERTER BASED ON MMC

Motivations: Develop flagship control examples for complex multilevel converters.
Objectives: Design, implement and validate the control for a 16.7 Hz to 50 Hz single-phase to three-phase direct AC/AC converter. The modeling and control implementation will be done on Matlab Simulink or PLECS. The experimental validation can be implemented as a downscaled mock-up of a power supply for railways.
Skills: A strong background in automated control is recommended.

RESONANT POWER CONVERTER FOR WIRELESS POWER TRANSFER

Motivations: Develop application examples using imperix products.
Objectives: Design, implement and validate a hardware prototype as well as suitable control for a wireless power charger using imperix products. The considered application is typically an electric vehicle.
Skills: Some previous experience in power electronics is recommended.

DIGITAL TWIN FOR THE HEALTH MONITORING OF A POWER CONVERTER

Motivations: Failure prevention often relies on the health (or condition) monitoring of key electric parameters, or the detection of a possible mismatch between actual measurements and those obtained from a digital twin model that is run in real time.
Objectives: Design, implement and validate a digital twin for power converter (to be selected), and identify the related use cases. The implementation will be done on Matlab Simulink or PLECS using imperix products.
Skills: Some previous experience in power electronics is recommended.

OPERATION OF A THREE-PHASE INVERTER AS A CONFIGURABLE MOTOR EMULATOR

Motivations: Working with powerful motors (>20-30 kW) involves significant mechanical forces and hence requires well-engineered test benches. Using emulated motors instead of real ones offers increased flexibility and reduces the related efforts.

Objectives: Develop flexible run-time models of induction motors and synchronous motors, which can be used for the closed-loop control of the related quantities. Various levels of detail (differential- and common-mode behavior, bandwidth, etc.) are considered. Implement and validate the results experimentally.

Skills: A strong prior knowledge of electric machines is necessary.

FPGA DEVELOPMENT PROJECTS

RAPID SYNTHESIS AND IMPLEMENTATION USING PARTIAL RECONFIGURATION

Motivations: Improve the build time of custom FPGA components by using or developing a fast C-to-bitstream toolchain.

Objectives: Explore how partial reconfiguration technologies can support High-Level Synthesis (HLS) and be used to develop custom blocks in the Imperix FPGA Sandbox.

Skills: Previous experience with FPGAs is required. Previous experience with HLS tools is recommended.

REDUNDANT COMMUNICATION FOR DISTRIBUTED CONTROL IN POWER ELECTRONICS

Motivations: The current implementation of the imperix "RealSync" protocol doesn't offer any redundant mode of operation.

Objectives: Study the possible types network redundancies and implement one. Investigate how to seamlessly switch the reference clock used for synchronization.

Skills: Previous experience with FPGA design is essential.

LOW-LATENCY COMMUNICATION USING PCI EXPRESS

Motivations: Power electronics typically involve closed-loop control with an interrupt period of 5-100µs. Latency is hence critical in systems that use both a CPU and an FPGA.

Objectives: Assess the achievable performance using PCIe for the communication between a multi-core ARM processor and a state-of-the-art FPGA. Implement the necessary Linux kernel and FPGA drivers, and evaluate their performance – using DMA – in terms of data transfer rates, latency, and system overhead.

Skills: Previous experience with embedded Linux and FPGA design is required.

FIRMWARE OPTIMIZATION FOR A MULTI-CORE FPGA SOC

Motivations: Leverage the architecture of the Zynq UltraScale+ to improve SW/FW performance.

Objectives: Study the Zynq UltraScale+ architecture and investigate how to improve data synchronization, integrity and isolation between cores. For instance :

1. Use a hypervisor (e.g., Xen, Jailhouse, etc.) to isolate Linux and imperix OS.
2. Port imperix OS to a Linux application or kernel driver.
3. Use HW features (e.g., IPIs) to exchange data between cores.
4. ?

Skills: Previous experience with embedded Linux and bare-metal development is desired.

SOFTWARE DEVELOPMENT PROJECTS

FLEXIBLE PERIPHERAL RESOURCE MANAGER FOR CODE GENERATION IN SIMULINK

Motivations: Validate the allocation of I/O and peripheral resources before compilation (within Simulink) instead of at the code startup (in the real-time hardware target).

Objectives: Implement a flexible resource manager and adapt the hardware abstraction layer accordingly. Develop support for all four imperix programmable controllers.

Skills: Previous experience with Matlab Coder is a plus. BSc level suitable.

AUTOMATED CODE GENERATION BASED ON OPEN-SOURCE SIMULATION SOFTWARE

Motivations: Some universities are now evaluating alternatives to Mathworks (Matlab, Simulink), notably due to the high cost of their products. This raises an interest for supporting automated code generation from open-source alternatives, such as SciLab+Xcos.

Objectives: Develop, implement and test an extension of the imperix ACG SDK to support code generation from SciLab+Xcos

Skills: Familiarity with Simulink Coder is a plus. Interest in open-source solutions is a plus.

OPTIMIZATION OF RENDERING PERFORMANCE FOR REAL-TIME SIGNAL PLOTTING

Motivations: Improve the responsiveness of our remote control and monitoring software by optimizing the process of plotting of the acquired signals.

Objectives: Examine the current state of our plotting library, i.e. how the signals are rendered and how hardware acceleration is leveraged. Evaluate the opportunities provided by the different libraries and how they could integrate into our application. Explore different ways to improve the back-end of the plotting library. Implement and test.

Skills: Previous experience with Qt and C++ is required. Familiarity with computer graphics and rendering is a plus.

DEVELOPMENT OF SIGNAL PROCESSING FEATURES FOR POWER ELECTRONICS

Motivations: Extend the capabilities of our monitoring software by implementing different signal post-processing procedures useful to the analysis of power electronic systems.

Objectives: Assist in choosing and developing algorithms for the time-domain and frequency-domain analysis of acquired signals. Implement these algorithms in a performance-aware manner within our current software architecture.

Skills: Previous experience with C++ and familiarity with signal processing is required. Experience with the Qt framework and power electronics systems is a plus.

ONLINE STRUCTURED DATA HANDLING FROM WITHIN A WINDOWS SOFTWARE

Motivations: Make the most important content of the imperix online knowledge base (documentation, code examples, scripts, etc.) available directly from within our monitoring software (Cockpit). Make this content directly searchable (search bar).

Objectives: Improve the data structuring on our knowledge base to improve searchability. Develop a suitable API to make the corresponding data available in Cockpit. Create scripts to easily download and use the files (such as compiling them).

Skills: Previous experience with full-stack development as well as C++ is recommended.

HARDWARE DESIGN PROJECTS

DESIGN OF A FLYBACK CONVERTER PROTOTYPE

Motivations: Showcase the usability of the B-Box in applications that cannot be easily implemented using imperix power modules

Objectives: Design and implement a flyback DC/DC converter, for instance used as a 800V-to-48V battery charger. This project comprises the design of the hardware and related control software, plus the experimental evaluation of the obtained results.

Skills: Prior experience with PCB design is desired.

DESIGN OF A GAN-BASED ACTIVE NPC (ANPC) POWER MODULE PROTOTYPE

Motivations: Develop a use-case example of a custom PCB design and its operation with B-Box. Obtain an opportunity to benchmark state-of-the art semiconductors.

Objectives: Design, implement and qualify a T-type ANPC half-bridge similar to existing modules, but using GaN semiconductors.

Skills: Prior experience with PCB design is highly desired.

ISOLATED POWER SUPPLY FOR POWER ELECTRONIC BUILDING BLOCKS

Motivations: Develop an auxiliary power supply for imperix power modules, which withstand an isolation voltage that is compatible with medium voltage applications.

Objectives: Design, implement and qualify a 12-to-12V, 12W supply with a 12kV isolation.

Skills: Prior experience in both power electronics and PCB design is highly desired.

DESIGN OF AN EMC FILTER WITH A 4-WIRE COMMON MODE INDUCTOR.

Motivations: Create a flexible EMC filter that works in both AC/DC and DC/DC applications.

Objectives: Develop a 4-wire common-mode inductor and perform a comparative study of filter topologies.

Skills: Prior experience in power electronics is highly desired. Prior experience with EMC is a strong plus. MSc level only.