INTERNSHIPS AND RESEARCH PROJECTS

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Addressed to: Any R&D-performing academic institution or industrial company

1. APPLIED PROJECTS IN POWER ELECTRONICS

MODEL-PREDICTIVE CONTROL (MPC) OF A NEUTRAL-POINT-CLAMPED (NPC) INVERTER

Motivations: The fast advance of power electronics imposes imperix to continuously confront its hardware and software to the evolution of control techniques. This contributes to grow its expertise in the field as well as provide detailed performance validation for specific cases and conditions.

Objectives: Implement with the B-Box RCP a working converter control using Model Predictive Control techniques (MPC). A basic three-phase grid-tied inverter can be considered, as well as a three-level Neutral-Point-Clamped topology (NPC). This project can be done either in C/C++ or Simulink, and be implemented to Hardware-In-the-Loop (HIL) simulation or a low-power prototype (2kW), or both.

Skills: Prior knowledge of Model-Predictive Control (MPC) highly recommended
General knowledge of power electronics preferable

DIRECT TORQUE CONTROL (DTC) OF AN INDUCTION MOTOR (IM)

Motivations: Imperix wishes to develop application examples that demonstrate the capabilities of its digital controllers (B-Box RCP and B-Board PRO) in various types of applications. This also contributes to grow the company's expertise in the field and provide detailed performance validation for specific cases and conditions.

Objectives: Implement a working example of a direct torque control (DTC) for an induction machine. This includes the design and implementation of the converter control as well as its practical validation on a downscaled prototype. Various implementation techniques can (and will) be considered, using both DSP and FPGA.

Skills: General knowledge of power electronics required
Prior knowledge of FPGA programming preferable

CONTROL OF A DOUBLY-FED INDUCTION GENERATOR (DFIG) FOR WIND TURBINES

Motivations: Imperix wishes to develop application examples that demonstrate the capabilities of its digital controllers (B-Box RCP and B-Board PRO) in various types of applications. This also contributes to grow the company's expertise in the field and provide detailed performance validation for specific cases and conditions.

Objectives: Implement with the B-Box RCP a working example of a complete closed-loop vector control for an DFIG. This includes the coding of the converter control as well as its practical validation on a Hardware-In-the-Loop (HIL) simulator.

Skills: General knowledge of power electronics and drives required

EVALUATION OF BALANCING TECHNIQUES FOR MODULAR MULTILEVEL CONVERTERS

Motivations: The fast advance of power electronics imposes imperix to continuously confront its hardware and software to the evolution of control techniques. This contributes to grow its expertise in the field as well as provide detailed performance validation for specific cases and conditions.

Objectives: Implement and compare two distinct modulation and balancing techniques for Modular Multilevel Converters. This includes the design and implementation of the converter control (C++ or Simulink, on DSP) as well as the underlying modulators (VHDL, on FPGA). The conducted developments will be validated on a downscaled prototype (4kW).

Skills: General knowledge of power electronics required
Prior knowledge of FPGA programming preferable

MODELING AND CODE GENERATION OF / FOR A DIGITAL CONTROLLER USING PLECS

Motivations: As of today, imperix's digital controllers (B-Box RCP and B-Board PRO) can be programmed either using C/C++ code or Matlab Simulink. Imperix wishes to support more automated code generation solutions such as using PLECS (PLEXIM).

Objectives: Develop and implement simulation models for imperix's digital controllers and power modules on PLECS as well as a blockset support for automated code generation. All developments will be validated using Hardware-In-the-Loop (HIL) simulation or a low-power prototype (2kW), or both.

Skills: General knowledge of power electronics required
Prior experience with PLECS is a plus

OVER-SAMPLED CONTROL FOR MULTI-PHASE POWER CONVERTERS

Motivations: In numerous cases, multi-phase or interleaved systems require special configurations of the sampling instants as to extrapolate correct average values of rippled signals. Several techniques can be used for that purpose.

Objectives: Explore, implement and validate various over-sampling scenarios in the context of interleaved DC/DC and DC/AC converters. Suitable control techniques will require to be developed as well. All developments will be validated using Hardware-In-the-Loop (HIL) simulation or a low-power prototype (2kW), or both.

Skills: General knowledge of power electronics required

PLL-BASED SYNCHRONIZATION TECHNIQUES FOR MICRO-GRID APPLICATIONS

Motivations: Imperix desires to offer to its customers a broad range of pre-configured and -optimized PLLs, especially suitable for microgrid applications, which are often characterized by grid unbalances and harsh harmonic conditions.

Objectives: Implement, test and qualify the performance of various techniques.

Skills: General knowledge of power electronics required

2. EMBEDDED SOFTWARE DEVELOPMENT PROJECTS

USER-CUSTOMIZABLE HUMAN MACHINE INTERFACE (HMI) FOR A DIGITAL CONTROLLER

Motivations: Imperix has developed a computer software for interacting in real-time with its digital controllers (B-Box RCP and B-Board PRO). This software provides R/W access to all user-defined variables during runtime as well as datalogging capabilities. Imperix wants to expand this interface by allowing its customers to draw their own visualization panel by drag-and-drop of pre-defined visual elements such as gauges, dials, buttons, sliders, etc.

Objectives: Develop (or re-use) visual elements in Qt, define the configuration process of each visual element (how it is linked with user variable in B-Box, which the user-accessible properties). Implement the plugin for BB control (C++ Qt-based) that handle user-drawn visualization panels.

Skills: Prior experience with C++ mandatory
Prior experience with Qt recommended

DEVELOPMENT OF A COMMUNICATION FRAMEWORK FOR A DIGITAL CONTROLLER

Motivations: Imperix's digital controllers are based on a Zynq SoC, in which one CPU (embedded Linux) is in charge of system supervision and communication while the other CPU (bare metal OS) handles the main control tasks. As of today, this configuration only supports Ethernet-based communication with the PC host. Support for other protocols and communication with other systems would be a plus.

Objectives: Develop a C/C++ framework allowing the communication with the Linux application that is agnostic to the communication protocol and could run on top of various protocols TCP/IP, CAN, UART, EtherCAT, OPC-UA, etc.

Skills: Mastery of low-level C / C++ mandatory
Prior experience with embedded Linux recommended

FPGA-BASED MULTI-PURPOSE SERIAL COMMUNICATION PERIPHERAL

Motivations: Imperix's B-Box RCP and B-Board PRO controllers offer numerous high-speed I/O capabilities, but currently lack pre-implemented and easy-to-use support for general-purpose serial communication protocols such as UART, I2C, SPI, RS232, etc.

Objectives: Develop a multi-purpose IP block (on FPGA) that provides support for various protocols and that can be easily configured from the operating system and further from the Simulink-generated application code. Various types of validation and demonstration can be considered

Skills: Mastery of C++ and VHDL mandatory

LONG-TERM, HIGH BITRATE DATALOGGING

Motivations: The B-Box RCP control platform possesses a large DDR memory that can be used for a long-term data recording or high bitrate datalogging. Enabling such a feature would be attractive for monitoring applications.

Objectives: Implement the complete firmware and software stack-up to use this memory, configure the logger and trigger it from the usual development environments. Test and validate the design. This project involves both DSP and FPGA programming (VHDL) as well as high-speed microelectronic.

Skills: Mastery of C++ and VHDL mandatory
Prior experience with multi-core systems is a plus

HARDWARE ACCELERATION ON ZYNQ FOR POWER ELECTRONIC APPLICATIONS

Motivations: System-On-Chip platforms such as the Xilinx Zynq allow to implement hardware accelerators that lower the execution time of the main processing tasks.

Objectives: Evaluate the hardware acceleration opportunities of a Zynq platform in the context of real-time control of power converters. Select and implement different options and verify their accuracy through benchmarks. Assess the potential benefits of using HLS generated IPs to build the accelerators. Compare the gain in term of execution time versus a software implementation.

Skills: Mastery of C++ and VHDL mandatory
Prior experience with High Level Synthesis recommended

DESIGN OF A PROGRESSIVE WEB APP TO SUPERVISE A REAL-TIME CONTROLLER

Motivations: Imperix has developed a computer software for interacting in real-time with its digital controllers (B-Box RCP and B-Board PRO), which provides run-time R/W access to all user-defined variables as well as datalogging capabilities. It is built in C++ and communicates using Ethernet. Imperix wishes to evaluate the benefits and drawbacks of transitioning to a progressive web app (PWA).

Objectives: Develop an embedded web-server and an API on the device side, allowing to control and exchange data with the web app. Then build the web app with the current functionalities of the utility software.

Skills: Prior experience with embedded web server and javascript highly recommended
Prior experience with Zynq recommended

TIMESTAMPING-BASED NETWORK FAILURE DETECTION FOR ETHERNET APPLICATIONS

Motivations: Imperix has developed a special protocol for ultra-low-latency communication between digital controllers in power electronics applications. The existing fault detection mechanisms could be improved, based on the various possible (multi-rate) sampling configurations. This would also offer attractive benefits at the HMI level, enabling to display and enforce a specific configuration.

Objectives: Design and implement an OSI layer 2 time-stamping mechanism as well as the corresponding processing and validation features.

Skills: Mastery of C++ and VHDL mandatory
Prior experience with multi-gigabit serial communication is a plus

3. DEVELOPMENT PROJECTS IN ELECTRONICS

WIRELESS POWER SUPPLY FOR MEDIUM-VOLTAGE POWER CONVERTERS

Motivations: The series-connection of power converter modules up to medium-voltage (MV) levels requires that the power supply of the local gate drive units can withstand an isolation of several kilovolts. In this context, imperix wishes to develop new wireless power supplies for its products, which can support several hundreds to kilovolts of galvanic isolation.

Objectives: Design and implement a wireless power supply (10W at 10kV). This includes the complete circuit design (PCB), magnetics design and assembly as well as system testing.

Skills: Knowledge in analog circuit design required
Prior experience with magnetics design recommended

DESIGN OF A HIGH CMRR VOLTAGE SENSOR

Motivations: Imperix would like to improve the performance of its existing voltage sensors.

Objectives: Develop, implement and test experimentally a voltage sensor that supersedes the performance of imperix' existing sensors. The related challenges are to arrange the design trade-offs between noise, CMRR performance, accuracy, bandwidth, isolation voltage and cost. Field application is in the kilovolt range.

Skills: General knowledge of analog circuit design and instrumentation mandatory
Some knowledge of electromagnetic compatibility required
Prior experience with power electronics recommended