imperix

Written by: nicolas.cherix@imperix.ch
Revision/release date: Rev. B – Tue 16 Nov 2021

PUBLIC DOCUMENT

INTERNSHIPS AND RESEARCH PROJECTS

COMPUTER / EMBEDDED SOFTWARE DEVELOPMENT PROJECTS

Written by: Imperix ltd, Rue de la Dixence 10, 1950 Sion, Switzerland
Addressed to: Any R&D-performing academic institution or industrial company

REMOTE GUI BUILDER TOOL FOR REAL-TIME CONTROL IN POWER ELECTRONICS

Motivations: Imperix is interested in adding new features to its real-time monitoring software "Cockpit", which can be easily implemented as add-on modules. Among them, a GUI builder module would allow users to create customized GUIs, specifically targetting their individual remote monitoring applications.

Objectives: Review existing tools eligible to develop an GUI builder (c++ dll, interpreted code, web interface, etc). Develop a framework and interface allowing the user to build his own GUI that interacts with imperix digital controllers. Develop a set of custom widgets to interact with the control code running on the controller. Link the generated interface with cockpit.

Skills: Good C++ coding skills, familiar with Qt framework, Affinity for UI design (Good sense of intuitive UI design).

Level: This project can be addressed by any student with the above skills set.

TRANSIENT WAVEFORM GENERATOR FOR REAL-TIME MONITORING SOFTWARE

Motivations: Imperix is interested in adding new features to its real-time monitoring software "Cockpit", which can be easily implemented as add-on modules. Among them, an advanced waveform generator would be very useful for testing control dynamics.

Objectives: Develop a GUI that allows the user to generate various reference steps, simulate different stimuli / perturbations, or import setpoint profiles and waveforms. Translate the waveform into a series of points, which can be interpreted by the digital controller (embedded C/C++). Write the counterpart code on the controller that interprets the waveform and coordinates the transient generator with the datalogger (virtual oscilloscope).

Skills: Good C++ coding skills (for both high-level programming and embedded C/C++), familiar with Qt framework, knowledge of OPC-UA a plus.

Level: This project can be addressed by any student with the above skills set.

REMOTE VISUALIZATION MODULE FOR A POWER CONVERTER CONTROLLER

Motivations: As of today, numerous status information (fault flags, front-end configuration, etc.) of the B-Box RCP controller is only visible to the user on the hardware device itself. This is a strong impediment to users who desire to operate the device remotely (e.g. from a control room or trough VPN). Therefore, imperix wishes to integrate into "Cockpit" a module that can made this information available remotely.

Objectives: Design and implement a "Cockpit" module with the following capabilities : display a graphical view of the B-Box peripherals and their configuration; display detailed timing information of the user control code (interrupt frequency, sampling phase, oversampling ratio, etc); display and I/O PWM configuration.

Skills: Good C++ coding skills, familiar with Qt framework, affinity for UI design.

Level: This project can be addressed by a bachelor student.

FULL-PROGRAMMABLE ANALOG FRONT END – EMBEDDED C++ & GUI DESIGN WITH QT

Motivations: Imperix is interested in adding new features to its real-time monitoring software "Cockpit". Among them, an interface to easily configure the analog front-end of the B-Box RCP is desired. In order to implement this, the complete stackup must be updated, from the computer-based software "cockpit" to the embedded micro-controller, passing through the embedded Linux core.

Objectives: Extend the existing SPI protocol to implement communication between the front panel of the B-Box and the supervising core (embedded Linux). Develop code on the supervisor for retrieving configuration data and status flags. Develop an API in Cockpit for exchanging these configuration data (low-level C++ in Cockpit and embedded C++ on the supervisor). Develop a GUI that allows monitoring the status and configuring the parameters of the analog front end.
(Bonus) Develop code on the B-Box, which allows a master unit to gather the configuration from the connected slaves via a custom Ethernet-over-SFP protocol.

Skills: Good C++ coding skills for both high-level programming and embedded applications, familiar with Qt framework, familiar with coding on embedded systems (embedded Linux).

Level: This project can be addressed by any student with the above skills set.

MULTIRATE DATA (PRE-)PROCESSING FOR FOR TIME AND FREQUENCY ANALYSIS

Motivations: Imperix is willing to improve the virtual oscilloscope present in its software "Cockpit". Notably, the capability to concurrently display and manipulate PWM signals together with measurements and control variables is desired. Also, additional time analysis functions are desired (basic mathematical functions, envelope detection, statistical analysis, etc.).

Objectives: Design and implement, in C++, a data pre-processing library suitable for manipulating these mixed-frequency data and prepare them for display in a computer-based software. Part, if not most, of the processing will eventually be off-loaded in the embedded Linux core of the digital controller. Among essential functions, data re-alignment (time-stamps), anti-alias filtering and statistical analysis is considered. The ergonomic integration within the existing virtual oscilloscope will also require to be carefully addressed by the student.
(Bonus) If time permits, the implementation of frequency analysis capabilities is also desired.

Skills: Good C++ coding skills. Solid background in digital signal processing.

Level: This project is best addressed by a master-level student.

IMPLEMENTATION OF POWER CONVERTER CONTROL ON AI-ORIENTED FPGA DEVICES

Motivations: Imperix wishes to investigate the usability of the latest AI-oriented FPGA for the high-performance control of power electronic systems.

Objectives: Get familiar with the Xilinx Vitis family. Port a significant part of the existing B-Box RCP software and firmware onto a suitable device, including relevant artchitectural changes. Benchmark performance results versus existing hardware.

Skills: Strong self-learning skills and autonomy with FPGA-based design is required.

Level: This project can be addressed by a master-level student.

LONG-TERM, HIGH BITRATE FPGA-BASED 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 is mandatory.
Prior experience with multi-core systems is a plus.

Level: The project is accessible to the bachelor level, provided rock-solid FPGA skills.

TIMESTAMPING-BASED NETWORK FAILURE DETECTION FOR ETHERNET APPLICATIONS

Motivations: Imperix has developed a unique 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 is mandatory.
Prior experience with multi-gigabit serial communication is a plus.

Level: The project is accessible to the bachelor level, provided rock-solid FPGA skills.