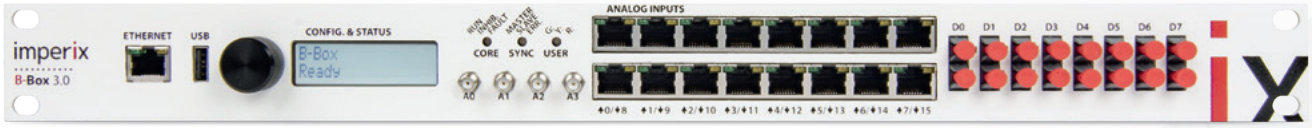
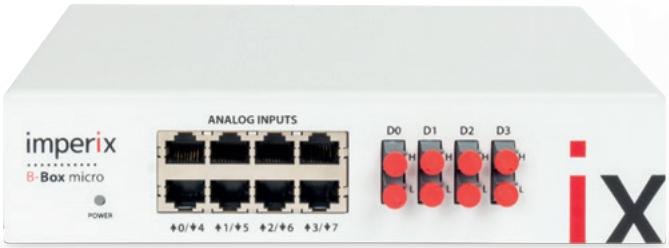
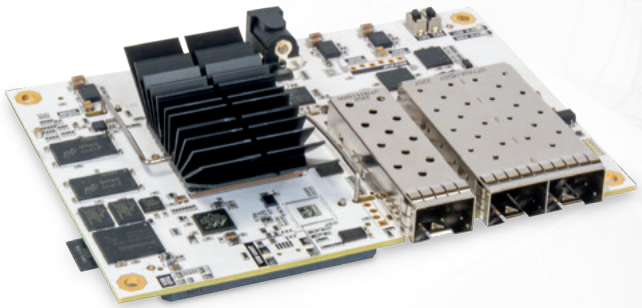
imperix

B-Box family 3.0

CONTROL SOLUTIONS FOR POWER ELECTRONICS







HIGH PERFORMANCE CONTROL
DEVELOPMENT AND TESTING

PRODUCTS OVERVIEW

Flexible equipment for power electronics prototyping

1 CONTROL SOLUTIONS

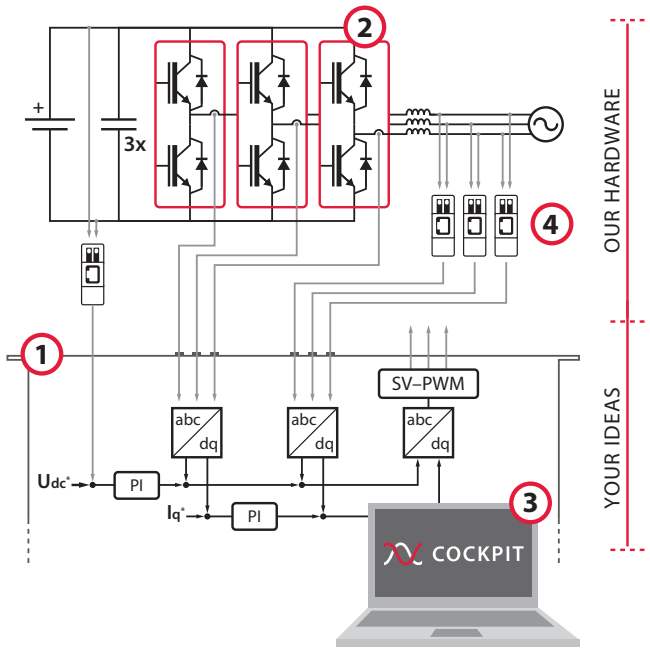
Imperix controllers are tailored for rapid control prototyping. They help engineers design, test, and validate digital control techniques for power converters.

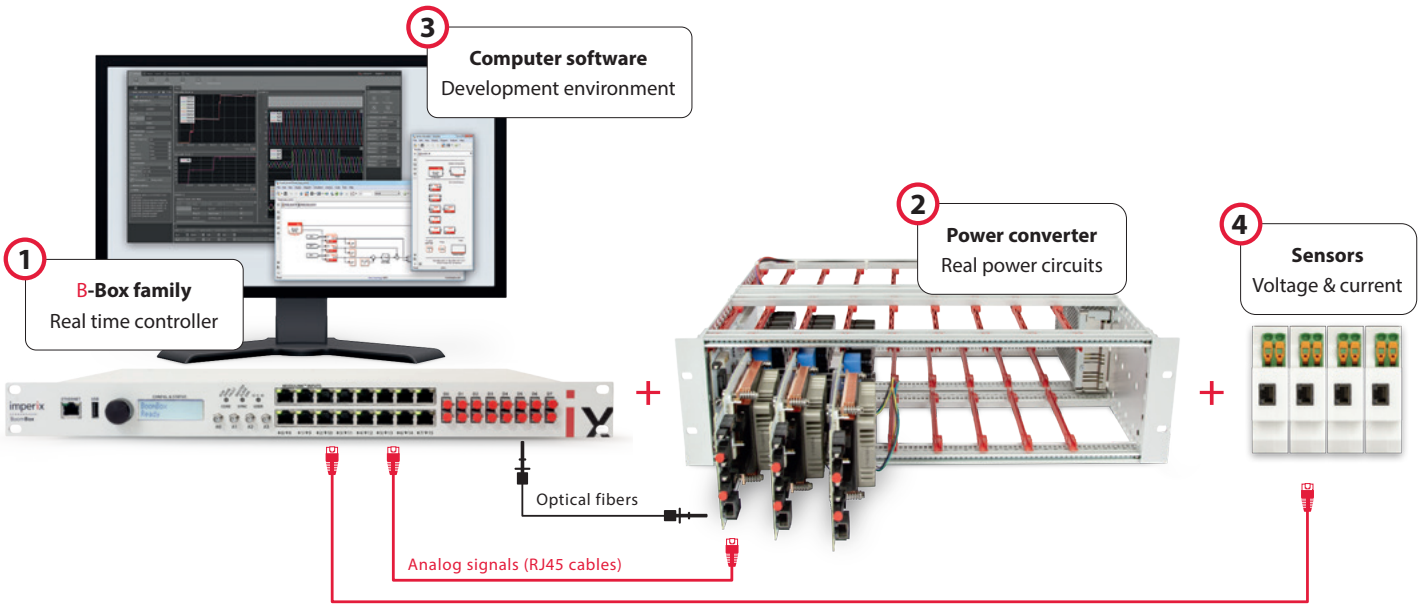
They embed a dual-core 1GHz ARM processor and a Kintex FPGA, offering state-of-the-art performance for closed-loop control applications up to hundreds of kHz.

2 POWER HARDWARE

Imperix modules are ready-to-use building blocks, featuring power semiconductors, embedded sensors and protections. They offer plug-&-play connectivity with B-Box controllers.

Together with flexible rack mounting options, they support the rapid implementation of virtually any sort of power converter topology in the 1–100kW range.





3 COMPUTER SOFTWARE

Thanks to a streamlined integration with Simulink and PLECS, our software accelerates the implementation of laboratory prototypes and the derivation of high-quality results.

In addition to automated code generation tools, our blocksets embed accurate simulation models, so that the behavior of the system under test can be precisely anticipated in simulation.

4 ACCESSORIES

Imperix offers various accessories, such as current and voltage sensors or electro-technical equipment, further facilitating the rapid implementation of prototypes and pilot systems.

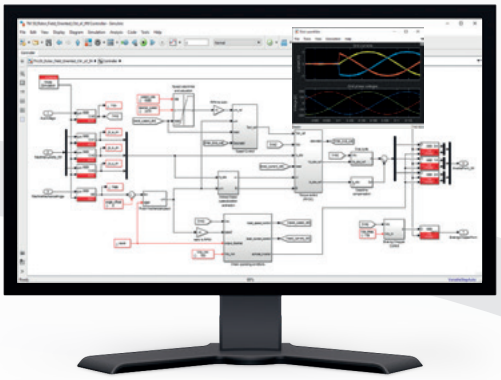
When needed, imperix may also offer integration and pre-wiring services, hence delivering prototypes as turn-key equipment. When applicable, product customizations are possible as well.

PROCESS OVERVIEW

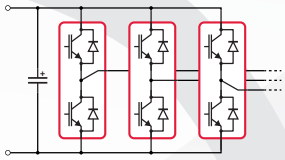
Speeding up power converter development and testing

A Start from the knowledge base

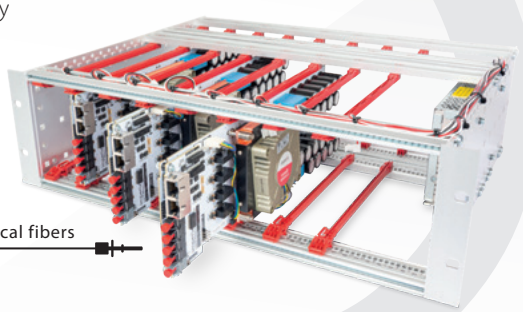
B Run an offline simulation



C Build an experimental setup



D Generate automatically the runtime code



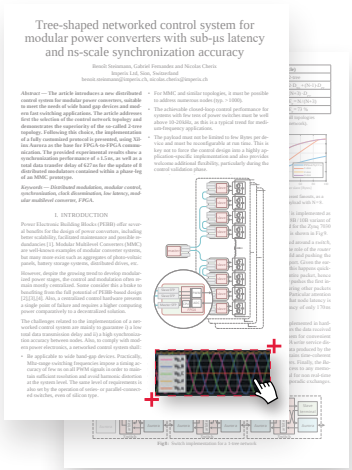
Optical fibers

Analog signals (RJ45 cables)

E Operate the system and export results

COCKPIT

F Create your publication or report



DIGITAL CONTROLLERS FOR POWER ELECTRONICS

A complete family of power electronic controllers

B-Box Micro

2

Cost-effective controller

- Limited I/Os
- Plug-&-play connectivity with power modules
- User-programmable FPGA
- Firmware-level protections

B-Box RCP

1

Flagship controller

- Numerous I/Os
- Configurable analog inputs
- Plug-&-play connectivity with power modules
- User-programmable FPGA
- Support for distributed control
- Hardware-level protections

B-Board PRO

3

Embeddable controller

- Board-level I/Os
- Small form factor
- User-programmable FPGA
- Support for distributed control
- Software-level protections

With their slightly different I/O connectivity, imperix controllers are tailored for different use-case scenarios. Nevertheless, as the are all embedding a B-Board PRO as their processing unit, their feature the exact same workflow and performance.

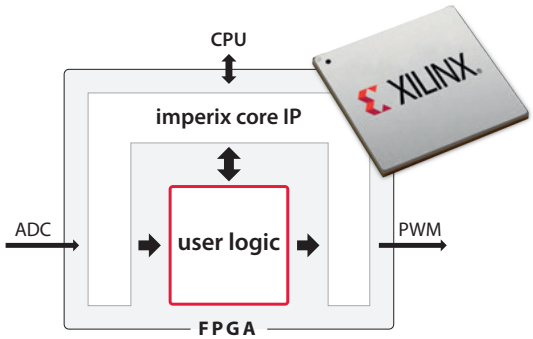
As such, any real-time executable code that is compiled for B-Box is also compatible with a B-Board. This portability not only offers great flexibility for research, but also strongly facilitates the transition outside of the lab, with small production series.

THREE CONTROLLERS FOR DISTINCT PURPOSES

- The B-**Box RCP** is a rapid control prototyping system, dedicated to laboratory applications.
- The B-**Box Micro** is a table-top controller, dedicated to teaching applications.
- The B-**Board PRO** is a fully programmable controller that can be directly embedded inside power converters.

Features	B-Box Micro	B-Box RCP	B-Board PRO
System on Chip	AMD (Xilinx) Zynq SoC (2x 1GHz + Kintex 7 125K)		
Number of ADC-channels	8x	16x	8x
Number of PWM-signals	8x optical	16x optical / 32x electrical	32x electrical
Plug-&-play with imperix modules	✓	✓	✗
Automated code generation	✓	✓	✓
User accessible FPGA	✓	✓	✓
Over-voltage/-current protections	Firmware	Hardware	✗
I/O extension over network	✗	✓	✓
Distributed control	✗	✓	✓

KEY FEATURES



USER-PROGRAMMABLE FPGA

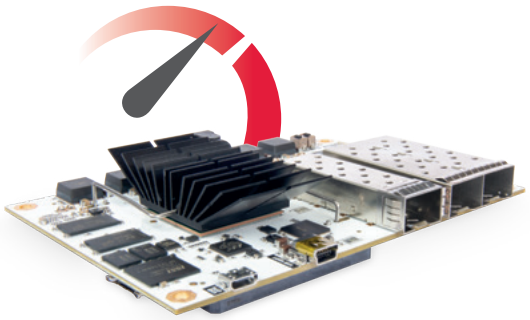
Absolutely no expertise in FPGA-based control design is needed to work with imperix controllers as they operate readily with a highly flexible and highly configurable FPGA firmware.

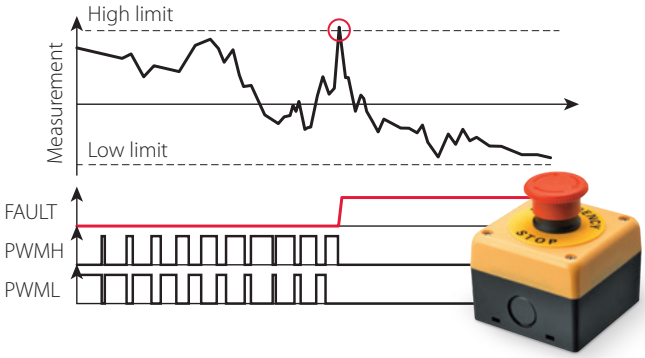
Nevertheless, for those who wish to implement additional control logic inside the FPGA, a dedicated user-programmable area is provided, with straightforward integration with the CPU side.

HIGH PROCESSING POWER

The control board hosts a 1 GHz dual-core processor, with one core dedicated to the real-time control tasks, and the other one responsible for the system supervision and data logging. Low-level tasks are also shifted in the FPGA, thereby saving valuable resources.

This guarantees exemplary performance, ranging up to 250 kHz control rates for simple systems, and still several tens of kHz for highly-complex multilevel converters with hundreds of I/Os.





SOFTWARE-INDEPENDENT PROTECTIONS

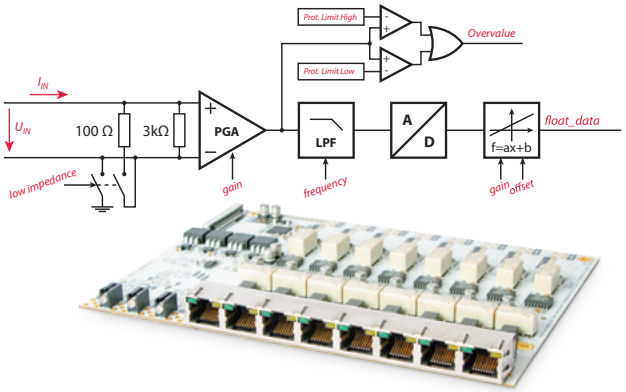
In case of abnormal or excessive operating conditions, the B-Box RCP instantly blocks its PWM ouputs, thanks to a dedicated hardware protection circuit. A similar mechanism is also available in the B-Box Micro, implemented inside the FPGA.

Imperix controllers also self-protected against faulty software conditions such as excessive computational burden (loss of real time) or critical algorithmic errors.

CONFIGURABLE FRONT-END (RCP ONLY)

Each analog input of the B-Box RCP features a fully-configurable signal conditioning and protection circuit. This provides a great flexibility for the quick and easy interfacing with a broad range of sensors in diverse applications. Each input channel features:

- 3 kΩ differential input or 100 Ω single-ended input
- Programmable protection thresholds
- Programmable gain amplifier and low-pass filter
- ±15V power supplies for external sensors



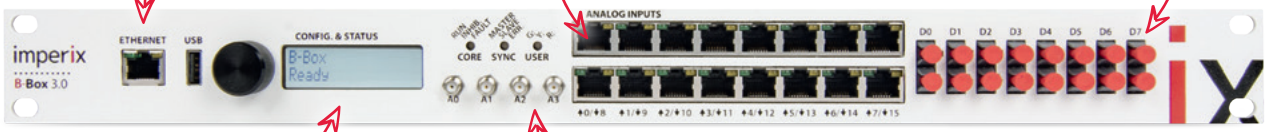
B-Box RCP

LABORATORY CONTROLLER

GIGABIT ETHERNET
- Programming & monitoring

ANALOG INPUTS
- 16 channels
- ±10V range
- High-Z full diff. or Low-Z single-ended
- Programmable gains
- Configurable low-pass filters (+ bypass)

OPTICAL PWM OUTPUTS
- 8 pairs or 16 independent signals
- 650nm plastic optical fiber (POF)
- Basic and advanced modulators
- Expansion available

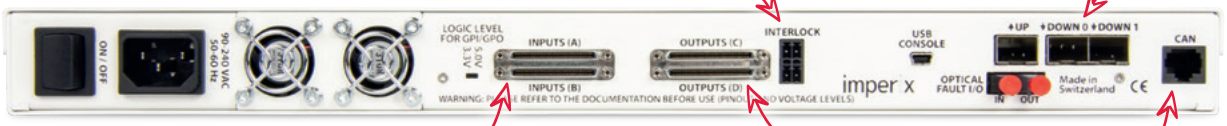


FRONT PANEL
- System status display
- Analog front-end configuration (e.g. protections)
- Easy configuration save/restore from/to USB key

ANALOG OUTPUTS
- 4 channels
- ±5V range
- Run-time configurable

SFP INTERCONNECT
- Multi B-Box I/O extension
- Ultra-low latency communication
- Native synchronization

ELECTRICAL INTERLOCK
- Inter-systems shared fault line



ELECTRICAL INPUTS
- 8x General purpose inputs
- 16x Fault inputs (e.g. driver feedback)
- 1x SPI / I2C link
- 36x User-configurable I/0s

ELECTRICAL OUTPUTS
- 8x General purpose outputs
- 16x PWM outputs

CAN
- Inter-systems communication
- Up to 1Mb data rate

TAILORED

The B-Box RCP is entirely designed with rapid control prototyping applications in mind. It is meant to be extremely quick and easy to use, while offering extensive flexibility so as to support all sorts of state-of-the-art applications in power electronics.

SCALABLE

Up to 64 RCP units can be easily stacked to build up larger controllers, extending up to thousands of I/Os! This brings high flexibility across projects, but also over time, as it always possible to combine existing controllers to adapt to future needs.

INDUSTRIAL-GRADE

The B-Box RCP offers a rugged mechanical design, inputs with extensive EMI protections and 19'' rack-mounting capability. This makes it perfectly suited for operation in industrial research laboratories and similar facilities.

FUTURE-PROOF

Thanks to its strong hardware abstraction layer, the B-Box RCP guarantees that a code that works today will keep working in the future, possibly with another hardware and in a different software environment.

HIGH-PERFORMANCE INTERCONNECT

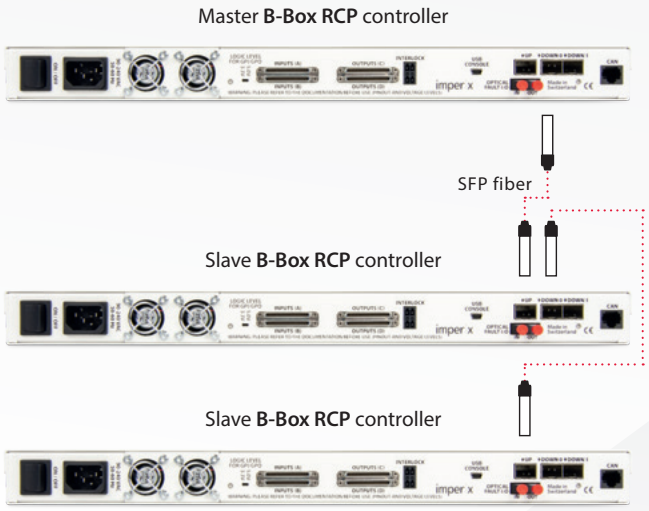
Imperix RealSync™ technology

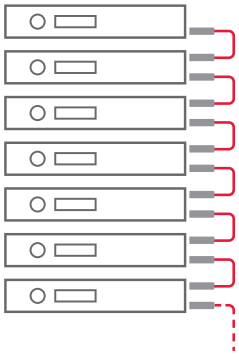
PERFECT SYNCHRONIZATION

Imperix's patented RealSync technology guarantees unrivaled synchronization accuracy across multiple units, down to ±2.0 ns! This is achieved thanks to clock dissemination throughout the control network, enabling multiple B-Boxes to operate as if they were one single unit!

HIGH-SPEED COMMUNICATION

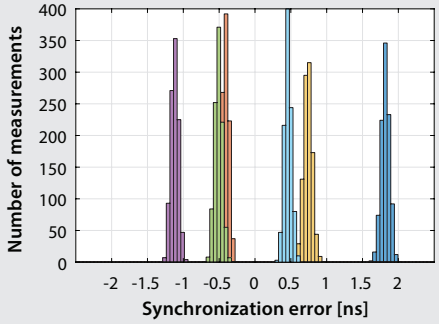
The 5 Gbps SFP optical links can be configured to create a tree-shaped network, achieving superior data bandwidth and lower latency over daisy-chain or ring topologies. This typically guarantees sub-µs data transfers in configurations with up to 8 controllers!



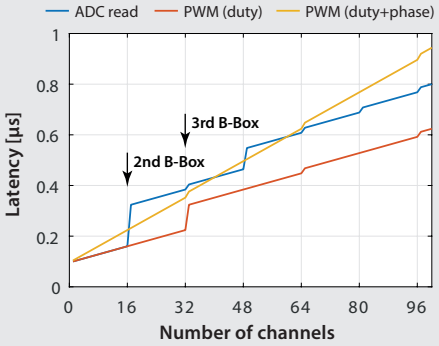


MAXIMUM I/O CAPABILITIES

Component		Single (1 unit)	Stacked (64 units)
Analog inputs		16x	1024x
PWM outputs	Optical	16x	1024x
	Electrical	32x	2048x
General-purpose digital outputs		16x	1024x
General-purpose digital inputs		16x	1024x



The synchronization between multiple B-Boxes is achieved without the user even knowing it! The guaranteed accuracy is ±2.0 ns.



Ultra-low latency is achieved, even with a high number of ADC or PWM channels. This allows closed-loop control frequencies up to 250 kHz.

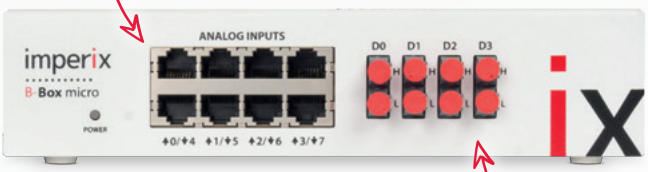
B-Box Micro

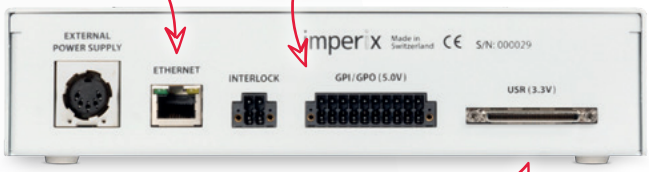
TEACHING CONTROLLER

ANALOG INPUTS
- 8 channels
- ±5V range
- Configurable safety limits

GIGABIT ETHERNET
- Programming & monitoring of the B-Box Micro

GPI/GPO CONNECTOR
- 8x Digital outputs (GPO 0-7)
- 8x Digital inputs (GPI 0-7)





OPTICAL PWM OUTPUTS
- 4 pairs or 8 independent signals
- 650nm plastic optical fiber (POF)
- Basic and advanced modulators

I/O EXTENSION
- 8x Digital inputs (GPI 8-15)
- 36x User-configurable I/Os

PLUG-&-PLAY

The B-Box Micro is directly compatible with imperix power modules, as well as current and voltage sensors. This greatly speeds up and secures the implementation of converter prototypes.

SIMULINK-COMPATIBLE

The B-Box Micro is a real-time target for Simulink or PLECS. Furthermore, the imperix blockset supports offline simulation, facilitating the pre-tuning and -testing of control algorithms.

SIMILAR TO B-BOX RCP

As the little sister of the RCP unit, the B-Box Micro unit offers the same compatibility with other imperix products, software and application examples.

SMALL BUT MIGHTY

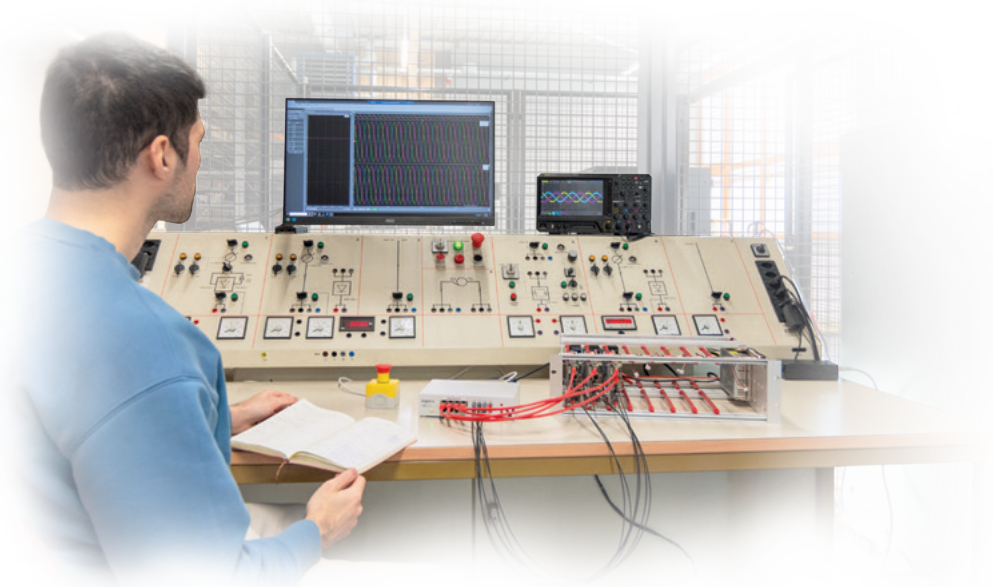
The B-Box Micro features a robust mechanical design and incorporates a multi-layered protection scheme. This ensures a «student-proof» experience and empowers them to learn.

10x STARTER KIT
FOR 10 WORK STATIONS

Volume discount

~~€199'810.-~~ €142'400.-

- 10x B-Box Micro controller
- 10x ACG SDK
- 10x open rack (type A)
- 40x PEB8038 modules
- 40x voltage sensors
- All needed cables



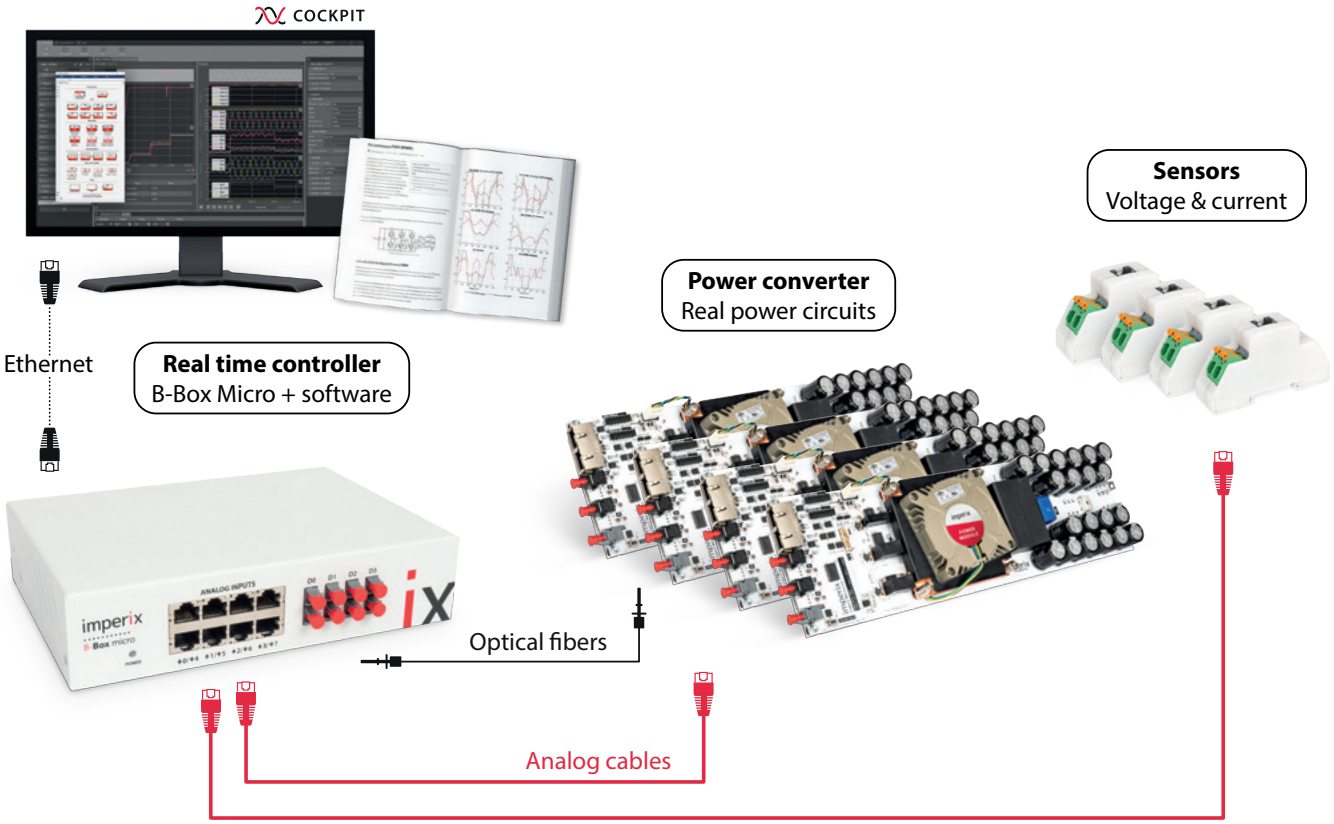
BUILD UP A CONVERTER IN TWO HOURS!

1 SELECT **THE EQUIPEMENT**
such as power modules, sensors, and controller.

2 BUILD **THE ELECTRIC CIRCUIT**
using the available mounting elements.

3 CONNECT **THE CONTROLLER**
simply wiring the plug-&-play connections.

4 TEST **THE OPERATION**
generating control from a Simulink / PLECS model.



APPLICATION EXAMPLES

The knowledge base gathers numerous technical articles as well as product-related documentation, which is available for free.

imperix.com/doc/

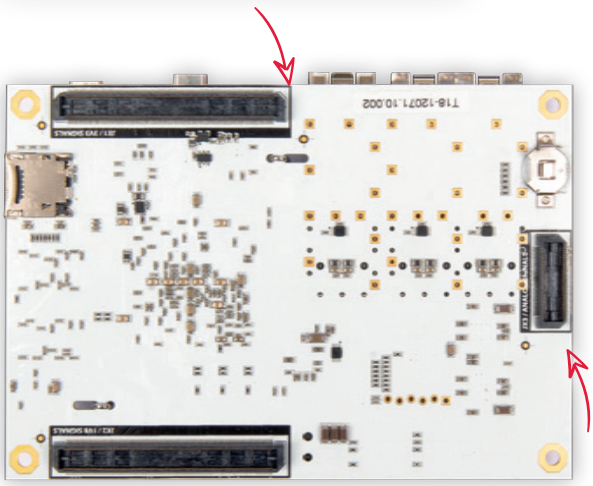
B-Board PRO

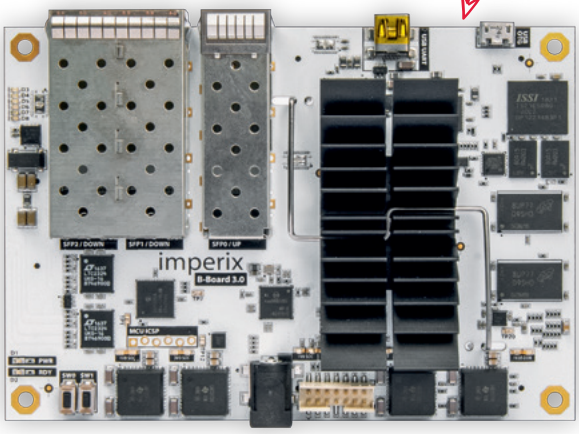
EMBEDDABLE CONTROLLER

BOARD-TO-BOARD SIGNALS
Two 160-pin high-speed connectors contain all digital signals to exchange with the B-Board. The logic level is 1.8V and 3.3V.

SFP INTERCONNECT
The RealSync technology offers unrivaled performance up to 64 units.

AMD (XILINX) ZYNQ
The Zynq 7030 offers high-performance computing and programmable logic.



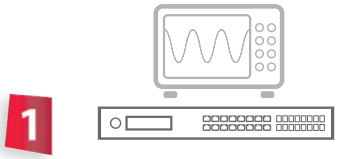


ANALOG INPUTS
Eight channels are available with up to 2 Msps with synchronous sampling.

FLEXIBLE POWER SUPPLY
The B-Board PRO requires a single is 5-15V power supply.

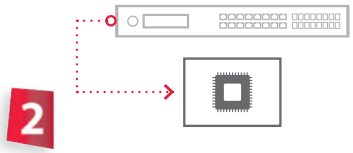
System on chip	Zynq XC7Z030-3FBG676E	
Processor	ARM Cortex A9 1 GHz 1GB DDR3	x2
FPGAs	Kintex 7 125K (user programmable)	x1
Analog inputs	16bits @ 2Msps	x8
PWM outputs	Electrical (PWM lanes 0-15, 1.8V) Electrial (PWM lanes 16-31, 3.3V)	x16 x16
User I/Os (high-speed)	Electrical (3.3V)	x36

Digital outputs	Electrical (3.3V)	x16
Digital inputs	Electrical (3.3V)	x16
Fault inputs	Electrical (1.8V) Electrical interlock	x16 x1
Incremental decoder inputs	3-pins (A,B,Z) (shared with GPI inputs)	x4
Communication	Ethernet 1 Gbps SFP+ 5 Gbps USB 2.0 (computer)	x1 x3 x1



USE B-BOX RCP FOR R&D

The RCP controller offers the same performance as the PRO module, but with additional flexibility, contributing to accelerating the development.



MIGRATE EASILY

Thanks to the exact equivalence between both controllers, software that was previously developed can be instantly ported. In fact, the very same bitfile can be used!

USE B-BOARD FOR PRODUCTS

The B-Board PRO is small enough to be integrated directly within power converters, yet powerful enough to support advanced applications.

FROM THE LAB TO THE FIELD!

Bridge the gap between prototypes and products!

DEVELOPMENT PHASE

- Flexible hardware
- Rapid control validation

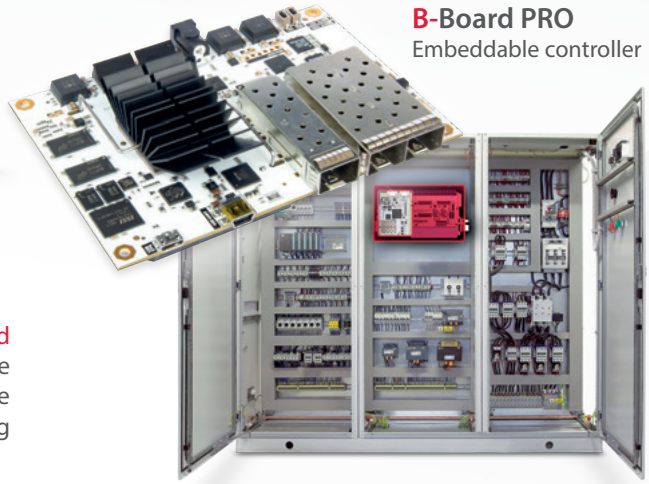
SEAMLESS TRANSITION

PRODUCTION PHASE

- Cost-optimized hardware
- Pre-validated control

FULL BITFILE COMPATIBILITY!

B-Box RCP
Prototyping controller

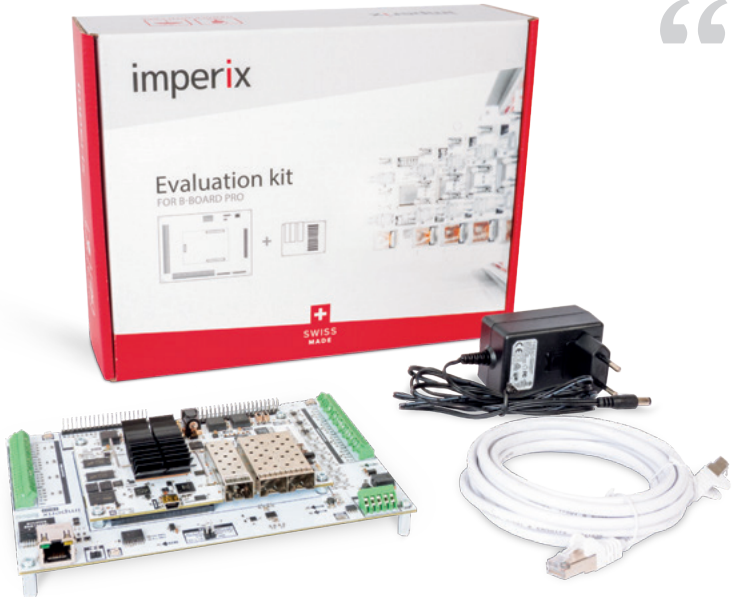


B-Board PRO
Embeddable controller

The exact compatibility between B-Box RCP and B-Board PRO allows benefiting from the increased flexibility of the rapid prototyping controller during developments, while using a lower-cost, product-embeddable variant during series production.

Evaluation kit

CARRIER MODULE FOR B-BOARD PRO



"The Evaluation kit is designed to quickly assess the tremendous capabilities of the B-Board PRO, right from the desktop.

CONTENT

Evaluation board	Carrier board	x1
B-Board PRO	Embeddable controller	x1
RJ45 cable		x1
Power supply	20W / 12V adapter	x1
Quick start guide		x1

PROGRAMMING

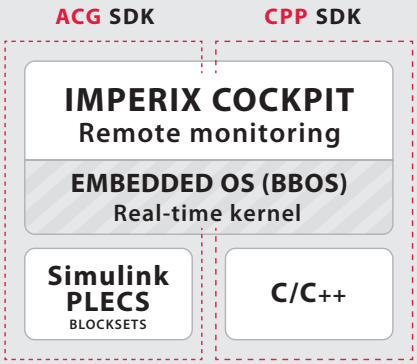
Software Development Kits (SDKs)

SOLUTIONS FOR REAL-TIME CONTROL DEVELOPMENT

Imperix offers two software development kits (SDK) for generating real-time control software for its real-time controllers.

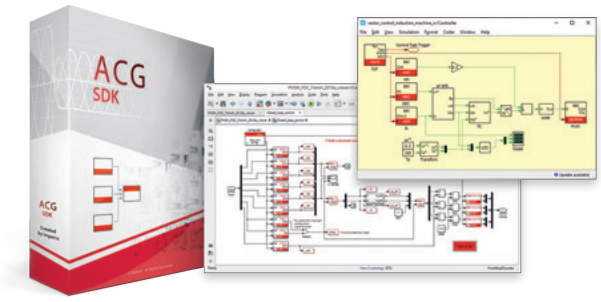
Both kits contain all the needed tools for the rapid prototyping of power converter control techniques, including simulation, code generation, debugging, and testing.

AVAILABLE SOLUTIONS



FEATURE	ACG SDK	CPP SDK
Real-time kernel (BBOS)	☑	☑
Blocksets for Simulink* and PLECS	☑	☐
C/C++ coding environment	☐	☑
Imperix Cockpit software	☑	☑
Code and application examples	☑	☑
User-editable FPGA area	☑	☑
Multi B-Box operation (I/O extension)	☑	☑

* Requires a valid MATLAB™ license issued by MathWorks™ and the following toolboxes: Embedded Coder, MATLAB™ Coder and Simulink™ Coder.



ACG SDK

The Automated Code Generation (ACG) SDK enables engineers to program imperix controllers directly from Simulink and PLECS. The provided workflow handles the fully-automated generation of code, compilation and upload in just one click.

In addition, the ACG SDK contains detailed simulation models of the controller peripherals and other products, so that the exact plant behavior can be simulated – and hence easily anticipated – before code is generated.

CPP SDK

The C/C++ SDK provides a direct approach to implement converter control algorithms without any simulation software. This may also offer slightly superior performance and flexibility over automatically-generated code.

The SDK contains extensive libraries, specifically developed to make the coding experience as simple as possible, while granting users direct access to each and every system parameter.

MONITORING

Real-time Monitoring Software

IMPERIX COCKPIT

Imperix Cockpit is a powerful monitoring software designed to facilitate the experimental testing of power electronics systems by leveraging the hardware capabilities of imperix controllers.

The software provides a set of non-intrusive tools that support the monitoring and tuning of any control variable in real time, allowing fast and easy validation of the control algorithm.

TRIGGERED SCOPES

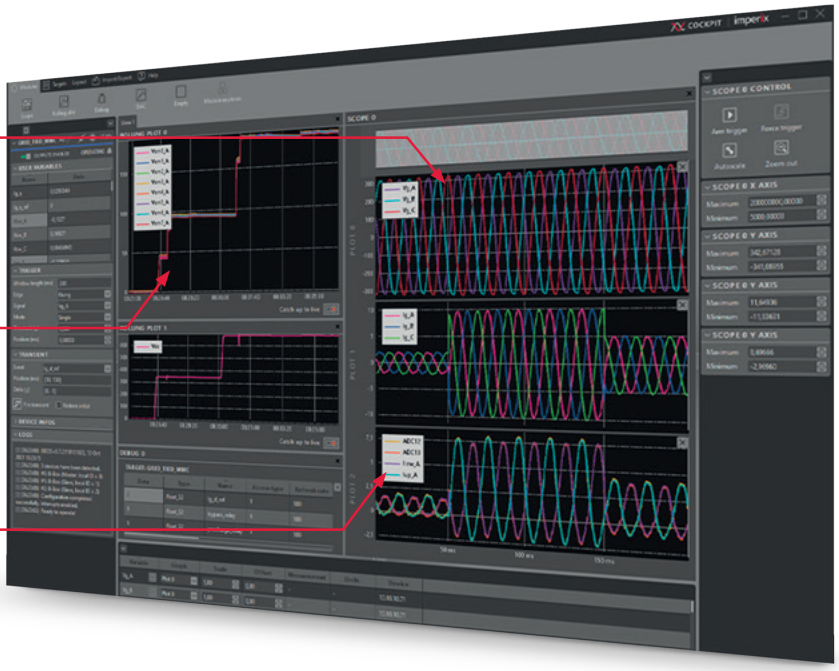
- Access to every control sample
- Oscilloscope-like trigger
- Export options

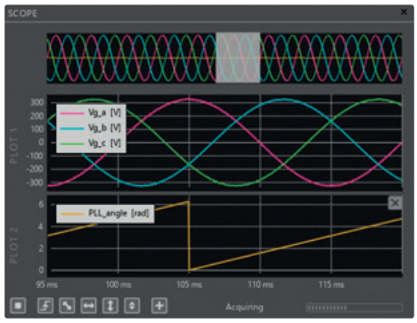
ROLLING PLOTS

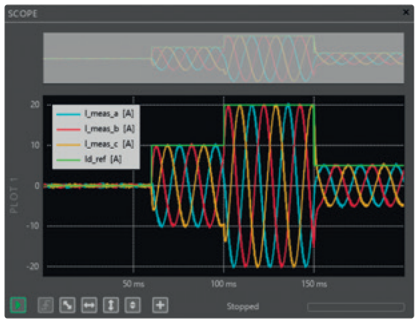
- Continuous update
- Long-term data logging
- Export options

TRANSIENT GENERATOR

- Configurable events
- Programmable steps on any variable
- Manual / auto triggering







TRIGGERED SCOPES

The scope can be used to display control signals on an oscilloscope-like interface. It captures each and every sample of the control variables, featuring up to 800 000 points for up to 32 variables.

TRANSIENT GENERATOR

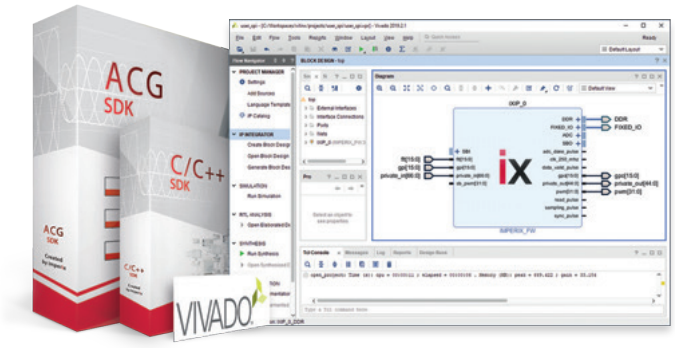
The transient generator is typically used to apply reference steps to selected control variables, enabling to easily evaluate, improve and document the plant's internal dynamics.

ROLLING PLOTS

The rolling plot displays a down-sampled version of control variables, allowing the monitoring of control variables for up to several days. Such data stream can also be obtained any other OPC-UA client.

FPGA CUSTOMIZATION

FPGA-BASED POWER CONVERTER CONTROL IMPLEMENTATION



Thanks to the high control rate achievable with sequential algorithms placed inside the main CPU core, most engineers prefer not to edit the FPGA logic, and rather leverage the ease of use offered by the automated generation of code from Simulink or PLECS.

However, advanced control applications can also benefit from the unused area available in the FPGA, which is freely editable for implementing special control tasks or extra communication options. To this end, relying on all the Vivado Design Suite and IPs, working with imperix controllers is similar to programming any other AMD FPGA.

Easy DSP to FPGA communication

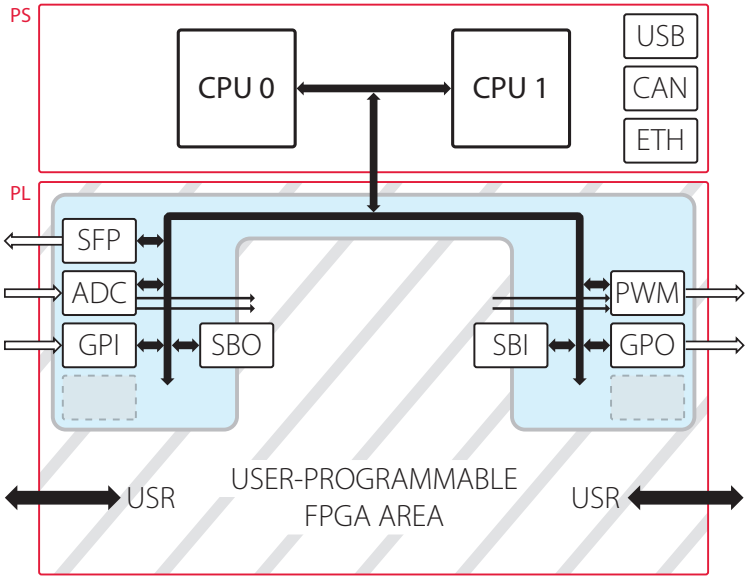
The imperix firmware IP provides a set of 128 registers named SBI and SBO. On the DSP side, drivers are provided to read or write in these registers with great simplicity.

Communication between CPU and FPGA is managed automatically, even across the network.

Dedicated high-speed user I/O pins

Among the numerous I/O available, imperix controllers notably offer a bus of 36 high-speed signals named USR, which directly links to the FPGA.

This bus offers great flexibility for implementing bi-directional interfacing with other equipment.



EXTENSIVE FPGA CAPABILITIES

The standard firmware IP only uses about 50% of the resources. The remaining logic is entirely available to the user.

NO ADDITIONAL LICENSE

The FPGA firmware can be edited and customized without any extra license, neither from imperix nor AMD.

EASY INTERFACING

Pre-written interface blocks exist on both the DSP and FPGA sides, so that users can integrate their own FPGA logic easily.

APPLICATION EXAMPLES

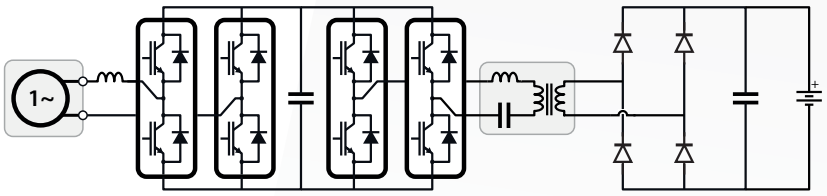
The knowledge base gathers numerous technical articles as well as product-related documentation, which is available for free.

imperix.com/doc/

APPLICATIONS EXAMPLES

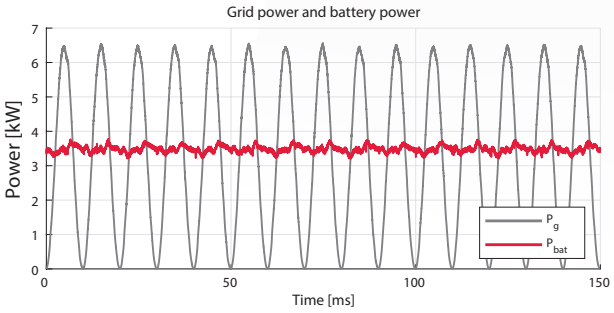
CPU-BASED ONBOARD CHARGER CONTROL

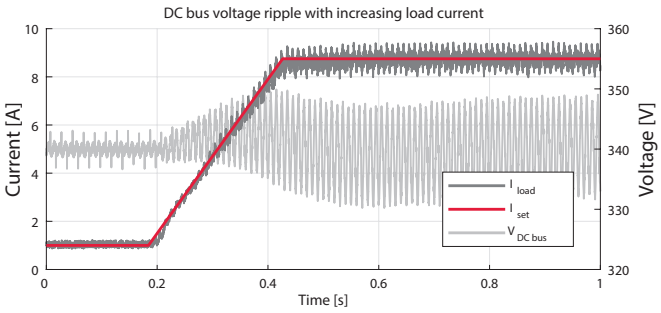
Single-phase totem pole PFC with isolated DC/DC converter

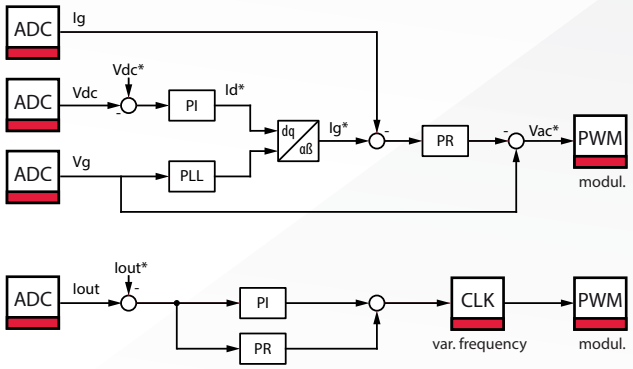


Research topics

- Modulation for totem-pole PFC
- PR control
- Resonant converters
- Battery charging strategy
- BMS development
- Transformer design

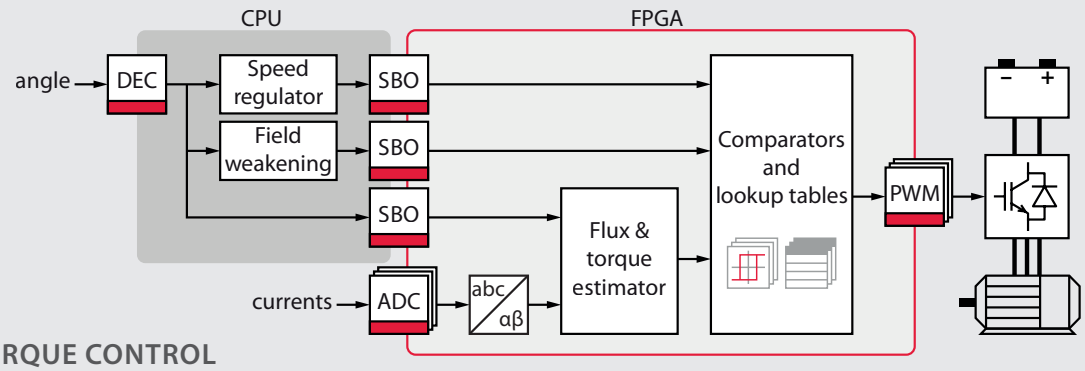






FPGA-BASED DTC USING VIVADO HLS

High-performance direct torque control example



DIRECT TORQUE CONTROL

DTC is an example of control implementation which benefits from sharing the control tasks between the CPU and the FPGA. This example is presented in TN133.

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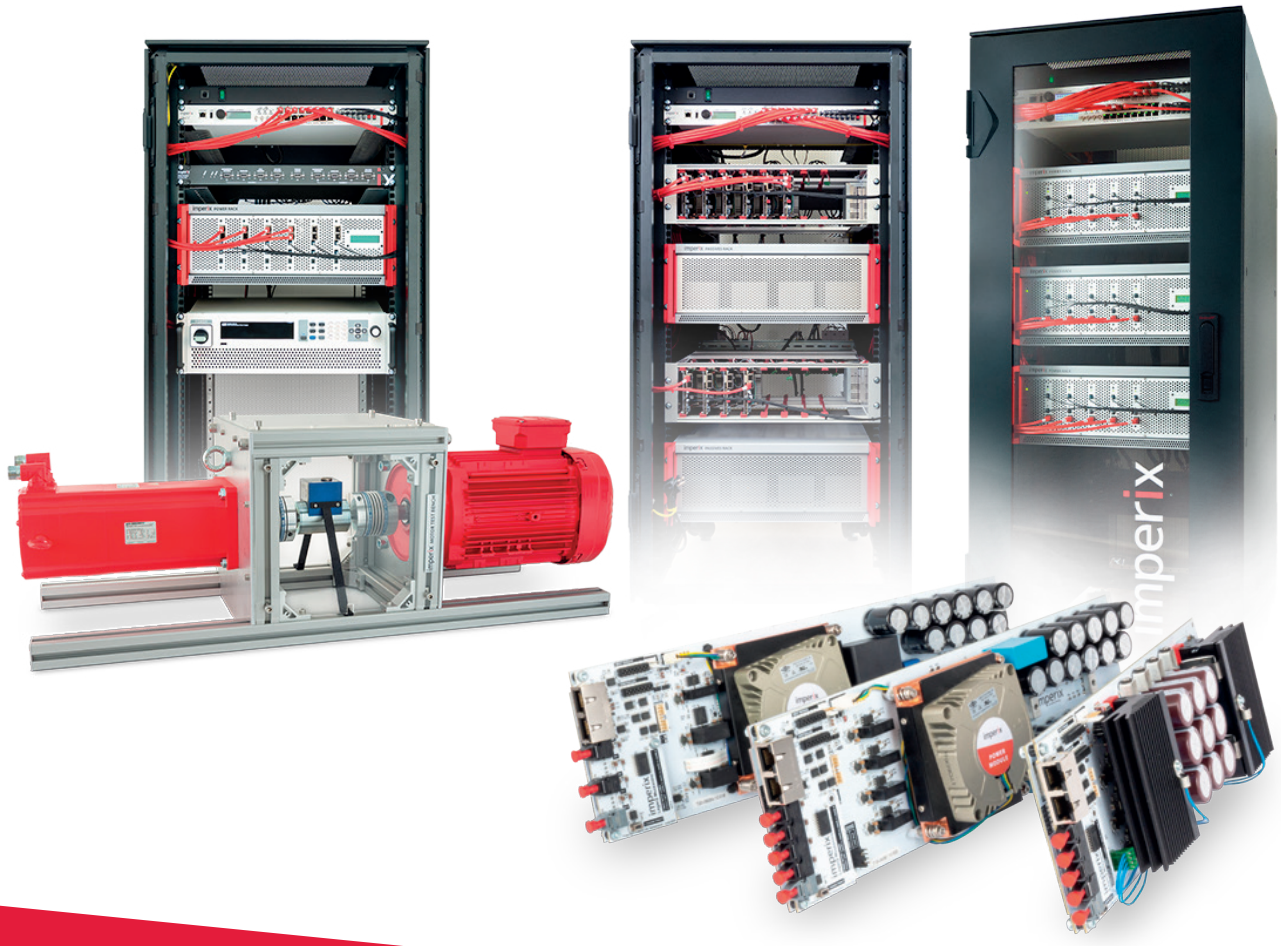

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