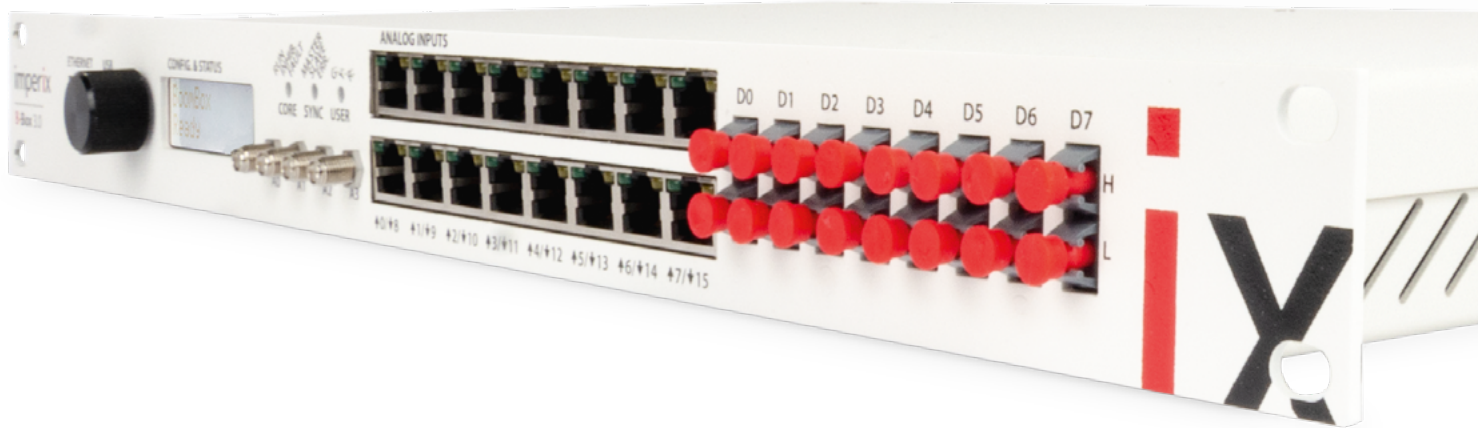# imperix

B-Box RCP^{3.0}
CONTROL PLATFORM

> " *The B-Box RCP accelerates the development and experimental validation of converter control techniques in a laboratory environment.*

THE ULTIMATE SOLUTION FOR FAST AND
RELIABLE DEVELOPMENT AND TESTING

ANALOG OUTPUTS

- 4 channels
- ±5V full-scale outputs
- Real-time configurable from the Cockpit utility software

ELECTRICAL INPUTS

Connector A
- 8x General Purpose Inputs (GPI 0-7)
- 16x Fault inputs (e.g. driver feedback)
- 1x SPI/I2C link

Connector B
- 8x General Purpose Inputs (GPI 8-15)
- 36x User-configurable I/0s

TAILORED DESIGN

The B-Box RCP is entirely and exclusively tailored to be a rapid prototyping controller. It notably distinguishes by the very high flexibility of its analog front-end and specialized I/O interfaces.

Also, B-Box RCP has been designed for synchronous sampling applications and a strict management of timings, from analog inputs to PWM outputs, including in stacked configurations.

HIGH-END DESIGN

B-Box RCP embeds the latest data processing devices, including a dual-core ARM processor and Kintex-grade FPGA.

Together with an ultra-light and specialized operating system, this guarantees state-of-the-art performance for all closed-loop control applications. Running a converter control algorithm in the hundreds of kHz range becomes no longer a challenge!

ANALOG INPUTS

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

OPTICAL OUTPUTS

- 16x PWM outputs (PWM 0-15)
- Rigorous pairs or independent signals
- Plastic optical fiber (650nm)
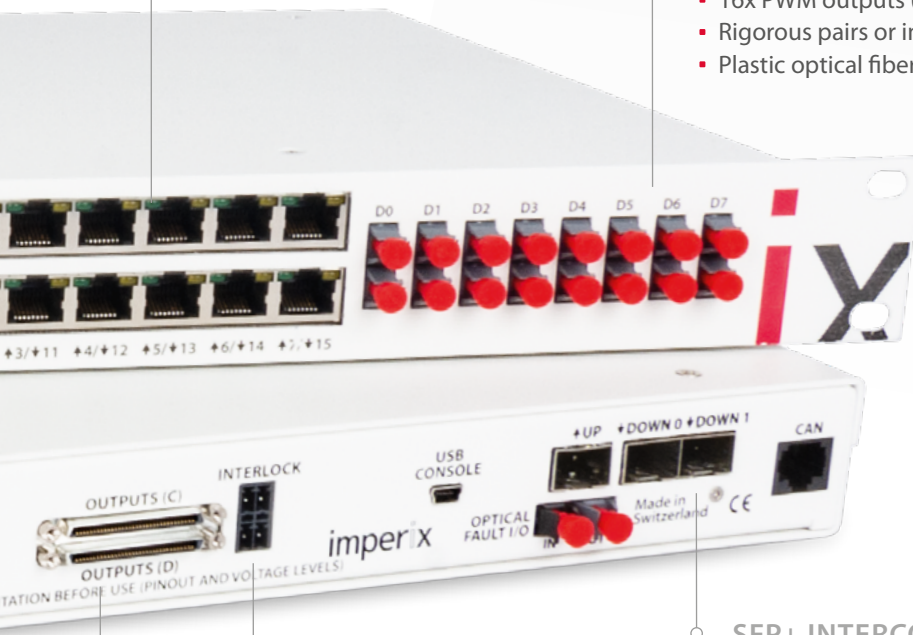
SFP+ INTERCONNECT

- I/O extension for inter-B-Box communication
- 5 Gbps RealSync™ link

INTERLOCK

- Inter-systems shared fault line
- Electrical and optical signalling

ELECTRICAL OUTPUTS

Connector C
- 8x General Purpose Outputs (GPO 0-7)
- 16x PWM outputs (PWM 0-15)

Connector D
- 8x General Purpose Outputs (GPO 8-15)
- 16x PWM outputs (PWM 16-31)

SCALABLE DESIGN

Multiple B-Box units can be stacked together to build up larger controllers. Up to 64 boxes can be combined, extending up to thousands of I/Os!

This brings high flexibility in time and across multiple projects. It is always possible to combine (or separate) units depending on the varying needs of their applications.

FUTURE-PROOF DESIGN

The B-Box RCP is built over a strong hardware abstraction layer, which guarantees the stability of its operation – as a platform – over time and accross the evolution of its own hardware.

This way, it is guaranteed that a code that works today will still work in the future, even though the hardware will most certainly have changed in-between.

KEY SPECIFICATIONS

2x **ARM 1**GHz	**NEW** **DSP**	**4** ns **PWM** resolution	**NEW** **FPGA**

134 user I/Os — **MORE** **I/Os**

System on chip	Zynq XC7Z030-3	x1
Processor	ARM Cortex A9 1GHz 1GB DDR3	x2
FPGAs	Kintex 7 125K (main) Artix 7 35T (auxiliary)	x1 x1
Analog inputs	16bits @ 500ksps	x16
Incremental decoder inputs	3-pins (A,B,Z) (shared with GPI inputs)	x4
PWM outputs	Optical Electrical (3.3V)	x16 x32

|		
User I/Os (high-speed)	Electrical (3.3V) (bi-directional)	x36
General-purpose I/Os	IN, electrical (3.3V / 5.0V) OUT, electrical (3.3V / 5.0V)	x16 x16
Fault inputs	Electrical (3.3V) Electrical interlock Optical interlock	x16 x1 x1
Communication	CAN Ethernet 1 Gbps SFP+ 5Gbps (RealSync)	x1 x1 x3

BENEFITS
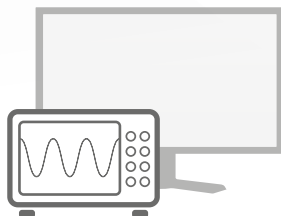
SWITCH FROM SIMULATION TO EXPERIMENTATION IN NO TIME

The B-Box RCP can be programmed with just one click directly from Simulink or PLECS. Besides, everything can be accurately simulated first, ensuring that everything that works in simulation also works in the real world!

GO EARLY TO THE LAB AND WORK STRAIGHT AHEAD WITH POWER

With the hardware protections present in the B-Box, engineers can start testing early and confront their models to real-world issues as soon as possible.
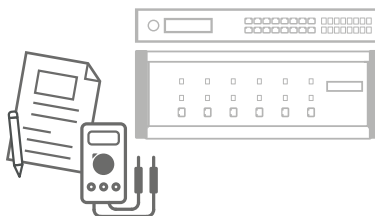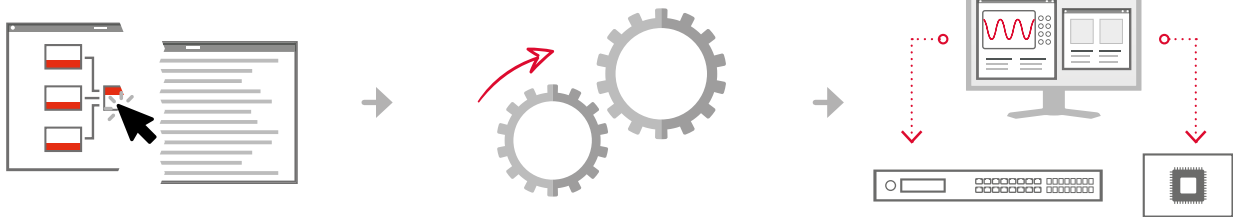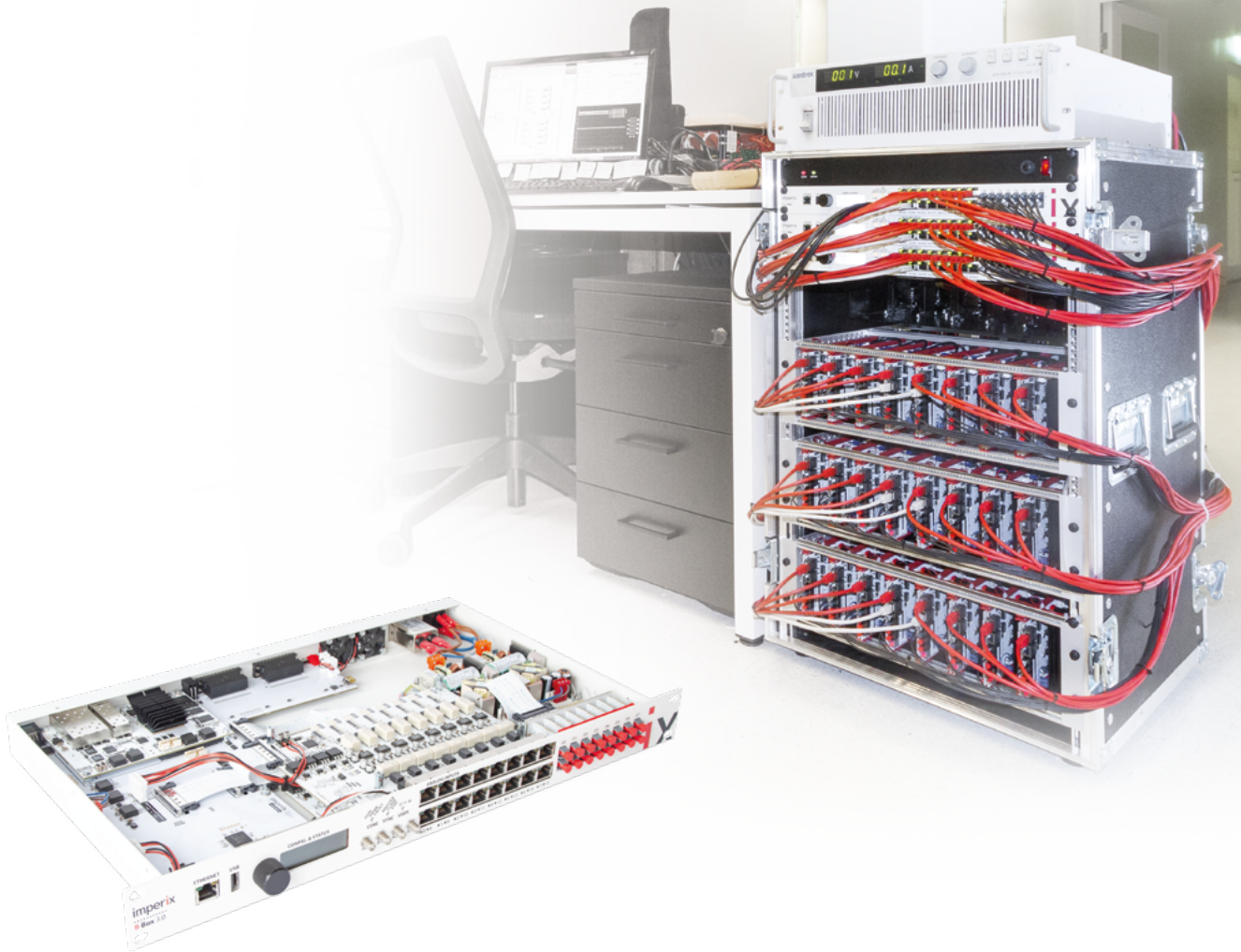
GENERATE HIGH QUALITY AND IMPACTFUL EXPERIMENTAL RESULTS

Thanks to the data logger embedded in the B-Box RCP, every signal can be observed, tuned and logged during run time. This allows to generate high quality measurements in the blink of an eye.

DEVICE & OPERATION

PROGRAMMING

The B-Box RCP has been designed to be easily programmed using C/C++ code as well as automated code generation from Simulink and PLECS.

All it takes to flash a control code on the B-Box RCP is one click. Code generation, compilation and upload on the device are fully automated.

Besides, no particular skills are needed to program the B-Box RCP; complete blockset and code libraries are readily available to make programming easy.

EXECUTING

B-Box RCP can be used alongside a computer or as a standalone device.

In both cases, a Gigabit Ethernet connection provides a programming access and a direct insight into the code's execution, thanks to the Cockpit utility software.

This way, B-Box RCP an be used as a desktop-based development platform, as well as an integrated controller within larger systems. This second scenario may be of interest in microgrids, where the focus is rather put on strategy-level aspects.

MONITORING

Cockpit is a computer software dedicated to the real time access to B-Box RCP and B-Board PRO controllers. It enables users to access, monitor and tune any variable in real time.

This software also has data logging capabilities that are similar to those of a high-end oscilloscope combined with a reference signal generator. It allows producing and capturing complex transients, while logging every point, thereby facilitating the tuning of control parameters.

WHAT'S INSIDE

"*Each B-Box RCP features no less than 2 FPGAs, a dual-core processor and several microcontrollers, enabling state-of-the-art performance and an unrivaled ease of use!*

1 PROCESSING BOARD

A high-performance embeddable controller at the heart of B-Box RCP.

The B-Box RCP is based on the high-performance B-Board PRO controller. It therefore ideally supports the very demanding needs of rapid control prototyping.

2 FRONT DISPLAY

A direct access to all details and settings from the front panel.

All individual settings of the analog input channels can be directly modified from the front panel. Status messages are also immediately made available.

3 AUXILIARY FPGA

The necessary hidden logic behind a highly flexible platform.

The Artix 7 FPGA located on the motherboard hosts all of the resident features of the B-Box RCP such as protection, signal mapping and internal monitoring.
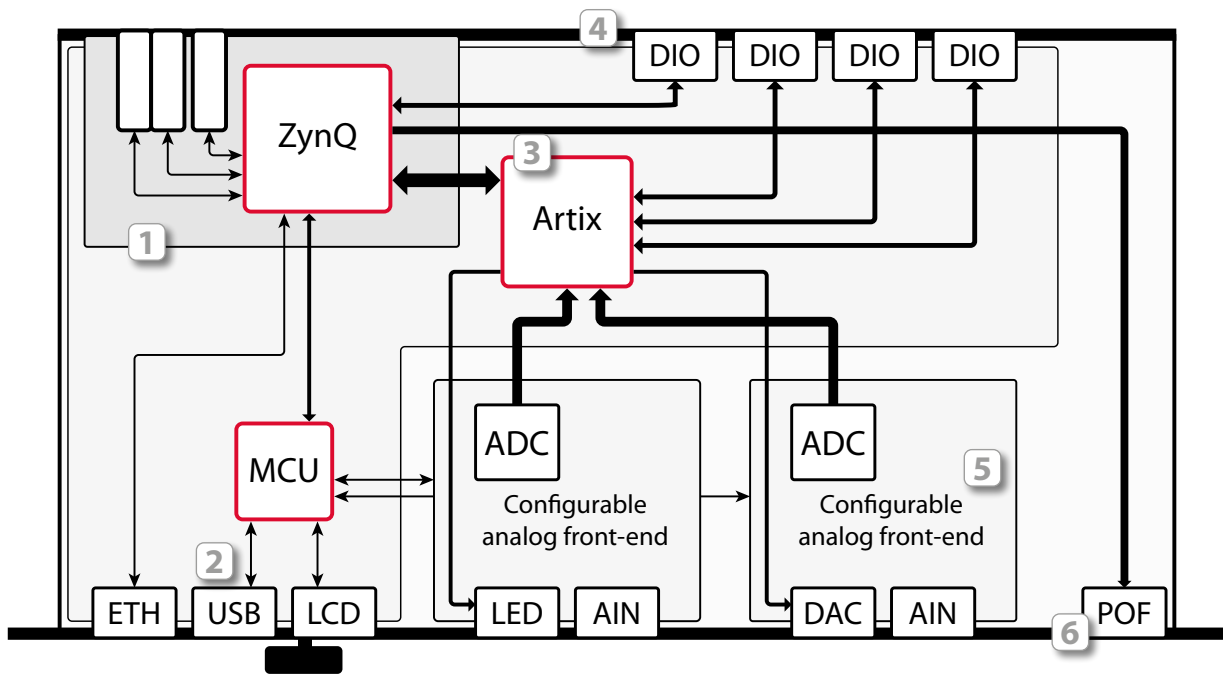
4 ELECTRICAL I/Os

High-performance I/Os for demanding control applications.

B-Box RCP offers hundreds of digital I/Os. Furthermore, thanks to their direct ties to FPGA logic, ultra-fast operation is possible with a bandwidth above 200 Mbps.

5 ANALOG FRONT-END

**A fully-configurable front-end within a power converter controller.**

With configurable impedance, gains and low-pass filter frequencies, the B-Box RCP is ready to accommodate any analog signal, with no additional interface board.

6 OPTICAL I/Os

Plug-and-play compatibility with imperix power modules.

With superior EMC performance, optical fibers are the preferred solution for conveying PWM signals, which are also 100% plug-and-play with power modules.

KEY FEATURES
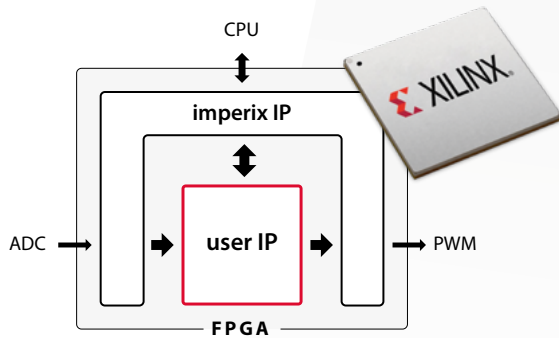
USER-PROGRAMMABLE FPGA

Absolutely no expertise in FPGA-based development is needed to work with the B-Box RCP, as it operates readily with a highly flexible and highly configurable FPGA firmware.

Nevertheless, for those who require to implement specialized control logic inside the FPGA, a dedicated area is provided, with straightforward integration within the DSP software kernel.

HIGH PROCESSING POWER

The B-Box RCP uses a 1 GHz dual-core processor. One core is dedicated to the closed-loop control tasks (dedicated kernel), while the other one is responsible for the system supervision (linux). Besides, most low-level tasks are shifted in FPGA.

Overall, this guarantees the complete dedication of a fast floating-point processor to real time control tasks, supporting best-in-class performance ranging up to 250 kHz closed-loop control frequencies.
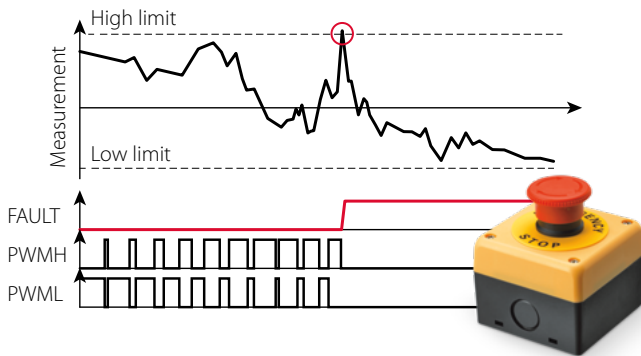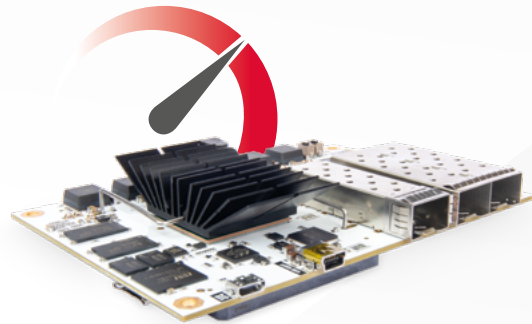
HARDWARE-LEVEL PROTECTION

In case of dangerous or faulty operating conditions, the B-Box instantly blocks all its PWM ouputs, thanks to a dedicated hardware protection circuit. This guarantees high level protections, entirely independently from both the DSP cores and the FPGA.

The B-Box RCP is also self-protected against faulty software conditions such as excessive computational burden or critical algorithmic errors.

HIGHLY FLEXIBLE FRONT-END

Each B-Box RCP possesses 16 highly-configurable analog inputs. This obviates the need to repeatedly develop analog signal conditioning interfaces for each project.

Each input channel features:

- 3 kΩ full-differential voltage-type input or 100 Ω single-ended current-type input
- Programmable safety thresholds
- Programmable gain amplifier and low-pass filter
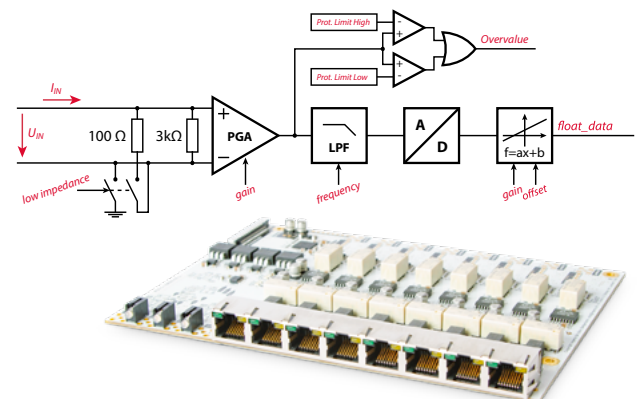
A HARDWARE FOR POWER ELECTRONICS

Tailored peripherals for best-in-class performance and convenience

## READY FOR ANY SENSOR

Highly flexible analog front-end

The B-Box distinguishes from other RCP platforms by its highly configurable and high-performance front-end. This allows to easily adapt to existing prototypes and/or allow to switch easily across several projects.

Characteristic	Setting	Value	Unit
Input impedance	High-Z	3.00	kΩ
	Low-Z	100.0	Ω
CMRR		> 72	dB
Signal-to-noise ratio (SNR)		> 88	dB
Accuracy (pre-calibration)		0.5 %	

Feature	Available settings
Input format	High-impedance, full differential
	Low-impedance, single ended
Programmable gains	G = 1, 2, 4, 8
Low-pass filter	F_{CUT} = 500 Hz – 40 kHz
	No filter (physical bypass)
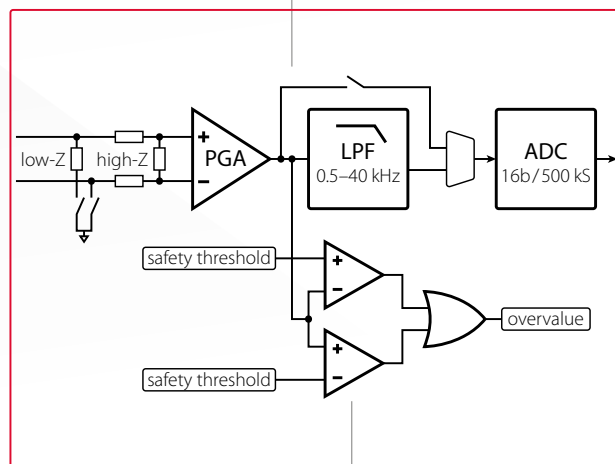
ANALOG FRONT-END
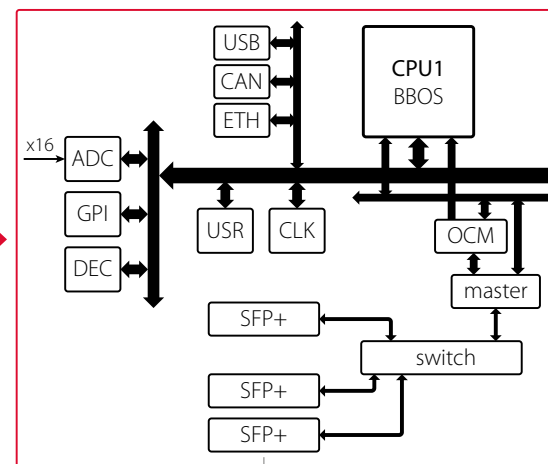
DSP+FPGA PROCESSING

READY FOR ANY MISTAKE

Software-independent protections

Each analog input channel posses individual programmable safety thresholds, which block the generation of PWM signals in less than 1 μs in case of an overvalue (e.g. overvoltage or overcurrent).

This mechanism is implemented at the hardware level, so that it is entirely independent from the operation of both the CPU and the FPGA. It is hence guaranteed to be effective even when the user application is still under debugging and not sufficiently reliable on its own.

READY FOR EXPANSION

Transparent I/O extension

B-Box RCP can be used in stacked configurations up to 64 units. Communication uses 5 Gbps optical fibers and the RealSync™ technology, which simultaneously guarantees an extremely low latency and a very high synchronization accuracy. Besides, this is totally transparent to the user so that nothing needs to be configured at any point in time. Slave I/Os simply work as if they belonged to the master.

High performance modulators

The newest B-Box RCP hardware supports a ultra-high time resolution of 4 ns (250 Mhz) on all its PWM signal generation processes. This guarantees a high angular resolution even in very fast-switching applications such as with Silicon Carbide (SiC) semiconductors.

Very-low jitter on all PWM signals is also guaranteed such that the overall temporal accuracy of all edges is also maintained up to the gate drivers. This way, very low dead times (typ. < 50ns) can be configured, hence minimizing distortion sources in very fast switching applications.

What's more, this is also guaranteed across several B-Boxes, thanks to the imperix RealSync™ technology!
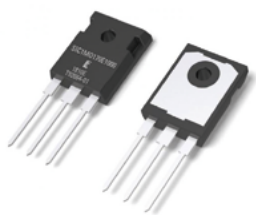
| Characteristic	Min.	Typ.	Max.	Unit
Resolution		16		bits
Operating frequency range (with 1 % angular resolution)	0.001		2'500	kHz
Output jitter/skew (single B-Box)		±4.5	±13	ns
(accross B-Boxes)		±6.5	±15	ns
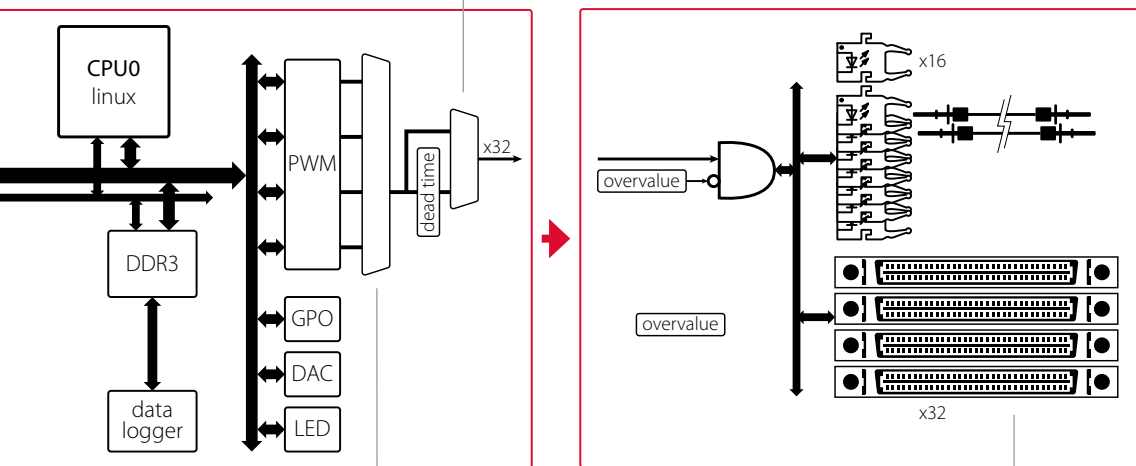
PWM OUTPUTS

READY FOR ANY MODULATION ALGORITM

Pre-implemented modulators

B-Box RCP supports a broad range of PWM techniques, thanks to dedicated modulators that are pre-implemented inside the FPGA.

This guarantees a safe and sound behavior and relieves users from the burden of implementing their own peripherals.

The B-Box RCP supports carrier-based and space-vector modulation, programmed pulse patterns, direct outputs and sort-and-select balancing and modulation for MMCs (Modular Multilevel Converters).

x32 CB-PWM
x4 SV-PWM
x4 PP-PWM
x2 SS-PWM
x32 DO-PWM
x1 SB-PWM
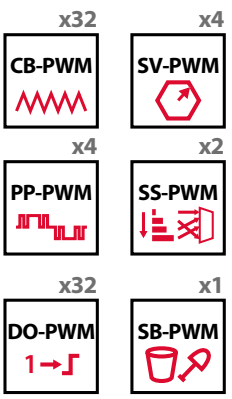
READY FOR ANY PROJECT

Multiple I/O expansion options

The B-Box RCP is designed to work with RJ45 analog inputs and fiber optical outputs. This is what is directly plug-&-play with imperix power modules.

Furthermore, numerous additional electrical I/Os are also readily available for other projects, or interfacing additional equipment. Fast bidirectional lanes are also available for custom-implemented FPGA firmware.

PROGRAMMING

Software Development Kits (SDK)
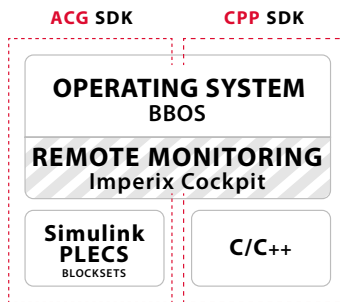

1 CLICK PROGRAMMING

ACG SDK

The Automated Code Generation (ACG) SDK enables engineers to program the B-Box RCP and B-Board PRO controllers directly from MATLAB Simulink and PLECS. The provided toolchain handles fully automated code generation, compilation and upload, in just one click.

In addition, the SDK contains simulation models of each controller peripheral, so that the exact system behavior can be simulated – and hence easily anticipated – before code is generated.

C/C++ SDK

The C/C++ SDK provides a direct way to implement converter control techniques without requiring any simulation software. This approach also offers 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.

ACG SDK		CPP SDK
OPERATING SYSTEM BBOS		
REMOTE MONITORING Imperix Cockpit		
Simulink PLECS BLOCKSETS		**C/C++**

Operating system + software blocksets	= **ACG** SDK
Operating system	= **CPP** SDK

FEATURE	ACG SDK	CPP SDK
BBOS operating system	☑	☑
Blockset for Simulink* and PLECS	☑	☐
C/C++ coding environment	☐	☑
Imperix Cockpit software	☑	☑
Code 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.

MULTIPLE HARDWARE

The very same software can be used for programming either the B-Box RCP or the B-Board PRO. Besides, thanks to the strict equivalence between both devices, user-level control software is also guaranteed to behave identically.

OPEN FRAMEWORK

Imperix SDKs being merely a set of tools, engineers remain in complete control of their control software. Everything can be edited and tuned down to the duty cycle! Furthermore, the FPGA firmware can also be modified for even more flexibility.

SOFTWARE FOR EVERYONE

Irrespectively of the level of expertise or field of use, the very same software can be used for teaching purposes, R&D activities or industrial applications. Everything is kept simple, allowing to accelerate any development.

REAL-TIME MONITORING

Imperix Cockpit software

PILOT YOUR POWER CONVERTER

Imperix Cockpit is a computer software that provides a powerful graphical user interface, designed to oversee the execution of the control software and have a complete view of what is happening inside imperix controllers.

Cockpit provides multiple tools for both observing and acting on the run-time code, without impeding its real-time execution. The software is ideally suited for system debugging and testing in the power laboratory.

Cockpit is included in both of imperix's ACG and C/C++ Software Development Kits (SDK).
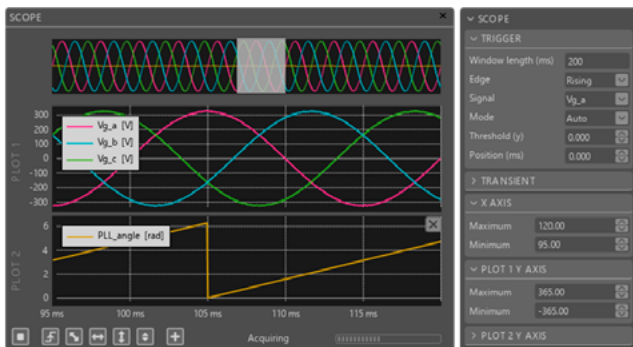

TRIGGERED SCOPING

EXTENSIVE MONITORING CAPABILITIES

Cockpit provides multiple monitoring tools. Whether it is to keep an eye on a variable or evaluate the transient response of new control algorithms, Cockpit possesses the right tool.

Once satisfying results are obtained, direct export is possible to Matlab, enabling easy integration in publications or test reports.

The software embeds multiple modules, transforming each target into a powerful signal acquisition and monitoring system.

The triggered scope works similarly to a 32 channels x 800 kpts oscilloscope with integrated reference generator. Reciprocally, the continuous data logger works for up to several tens of hours.
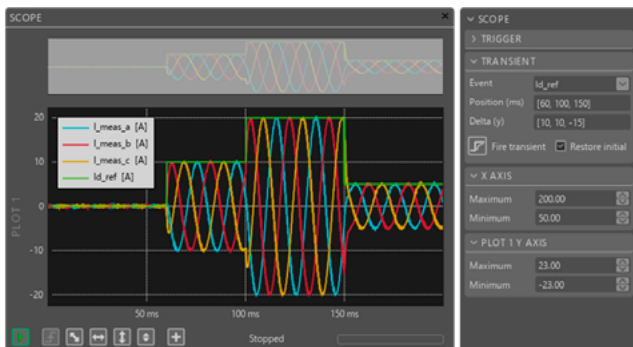
TRANSIENT GENERATION
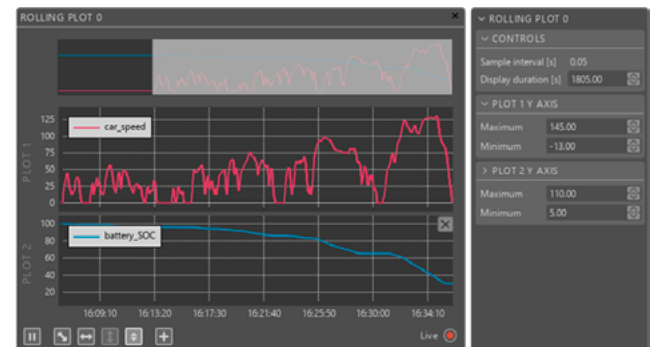
CONTINUOUS DATA MONITORING

SOLUTIONS FOR THE INDUSTRY

From the lab to the field!
BRIDGE THE GAP BETWEEN PROTOTYPES AND PRODUCTS!

" *What if you could simply take the result of your research and put it into an affordable controller, directly embeded inside your own products?*

SEAMLESS TRANSITION

DEVELOPMENT PHASE

- Flexible hardware
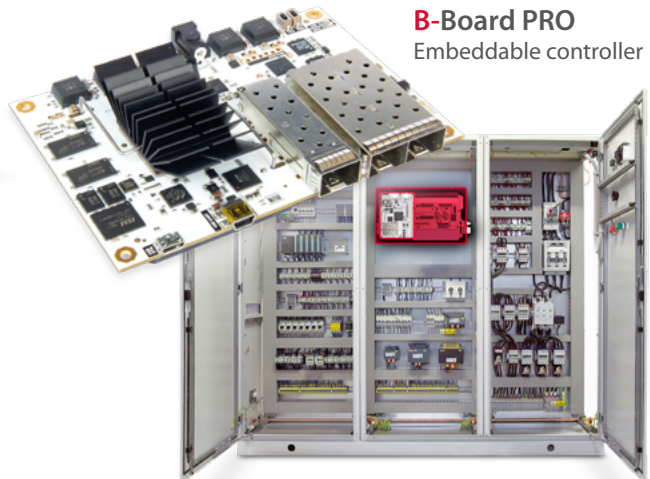- Rapid control validation

PRODUCTION PHASE

- Cost-optimized hardware
- Pre-validated control

FULL BITFILE COMPATIBILITY!

B-Board PRO
Embeddable controller

B-Box RCP
Prototyping controller

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

BITFILE COMPATIBILITY

The FPGA-based abstraction layer present in B-Box RCP and B-Board PRO guarantees the exact same performance (especially timings) on both devices.

SMALL FORM FACTOR

Despite its numerous I/Os, the B-board measures only 86x124 mm. It is therefore small enough to be mounted within most industrial control systems.

PROCESSING POWER

The 3rd generation of controllers rely on dual-core processors and modern FPGAs for best overall performance in demanding applications.

HIGH-END 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 through advanced clock dissemination through the optical fibers, 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 guarantees sub-microsecond data transfers in many configurations with up to 8 controllers!

Master **B-Box RCP** controller

SFP fiber

Slave **B-Box RCP** controller

Slave **B-Box RCP** controller
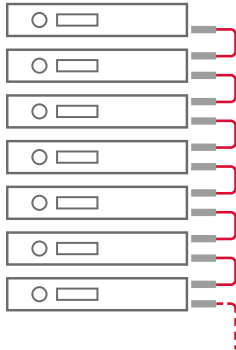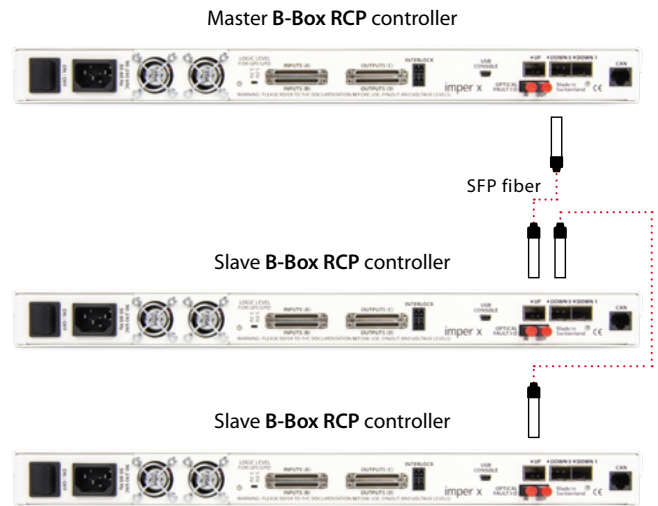
MAXIMUM I/O CAPABILITIES

Component		Single (1 unit)	Stacked (64 units)
Analog inputs		16x	1024x
PWM outputs	Optical	16x	1024x
	Electrical	32x	2048x
General-Purpose digital Outputs (GPO)		16x	1024x
General-Purpose digital Inputs (GPI)		16x	1024x
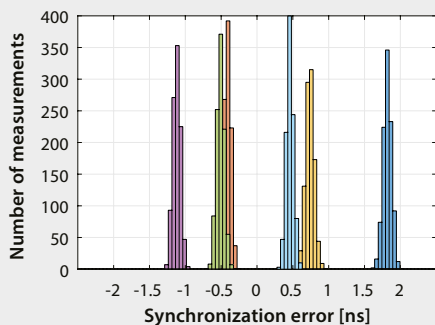
The synchronization between multiple B-Boxes is achieved without the user even knowing it! The guaranteed accuracy is ±2.0 ns.
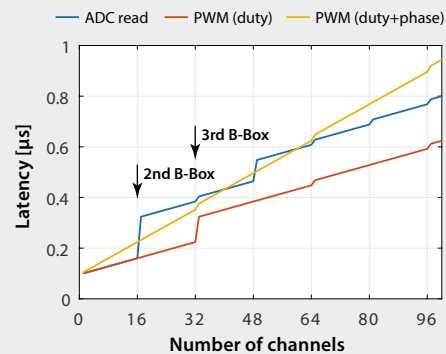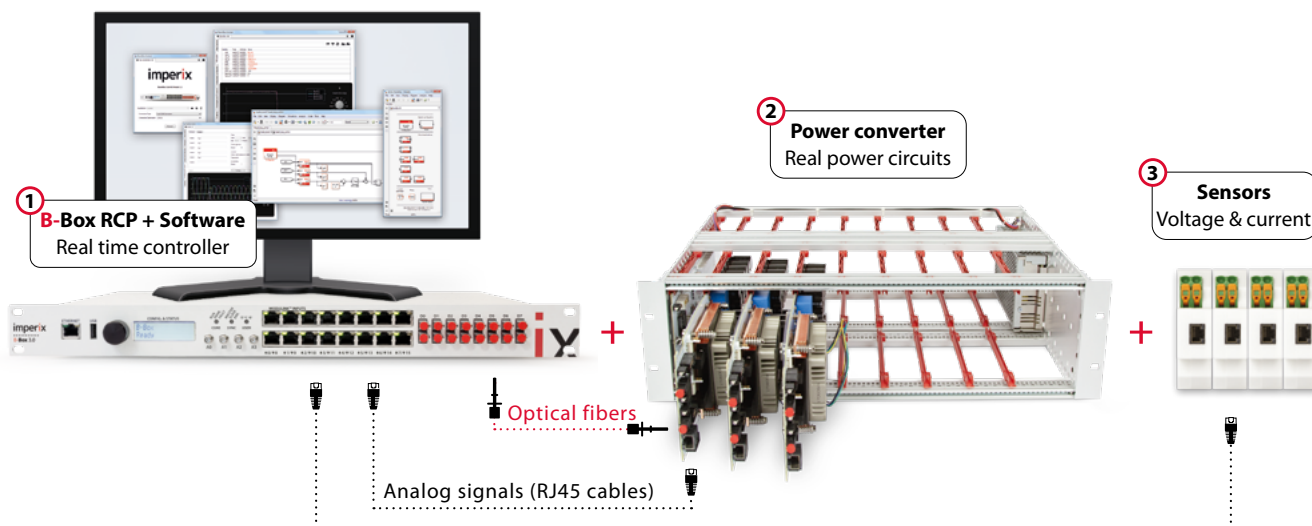
Ultra-low latency is achieved, even with a high number of ADC or PWM channels. This allows closed-loop control frequencies up to 250 kHz.

POWER ELECTRONICS PROTOTYPING

PLUG-AND-PLAY SOLUTIONS

By combining imperix control and power hardware with dedicated software and accessories, users benefit from a broad range of prototyping equipment, suitable for everyone's need and ambition.

① B-Box RCP + Software
Real time controller

② Power converter
Real power circuits

③ Sensors
Voltage & current

Optical fibers

Analog signals (RJ45 cables)

STARTER KITS
DEVELOP AND BUILD UP
SYSTEM PROTOTYPES WITHIN MINUTES!

When combined together, our products are ideally suited for laboratory research and teaching applications. They possess all the features – ranging from ease-of-use to robustness – to be safely put in the hands of engineers and even students.

Starting kits and specialized product bundles are also available on imperix.com/products/bundles, which makes it possible to start working in the lab straight away, with almost no start up time.


INTEGRATION LEVELS

Imperix products can be delivered as bare and independent products, fully turnkey systems, or anything in-between.

POWER RATINGS

Imperix products are well suited for the implementation of power converter prototypes ranging from 100 W to 100 kW.

INTER-OPERABILITY

Imperix products are plug-and-play when used together, but can also be used with any other controller or power stage.
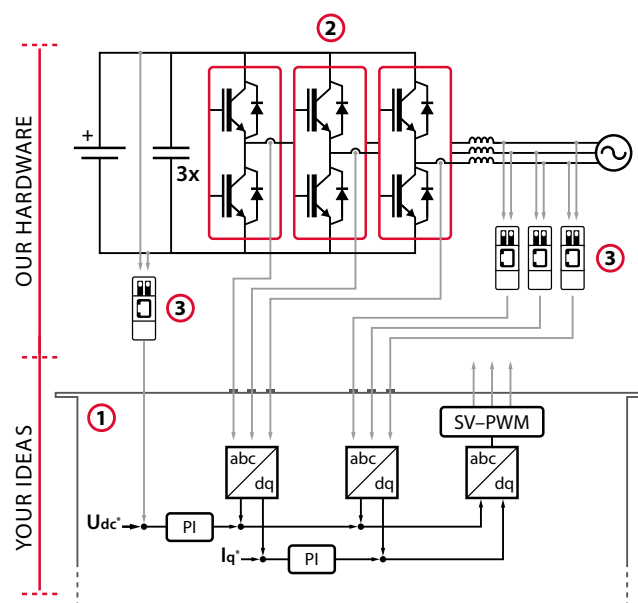
ACCESSORIES

Imperix provides several accessories that also contribute to facilitate the implementation of laboratory-scale converters.

SOFTWARE EXAMPLES

Imperix is currently building a complete knowledge base of control code and software examples, available free of use.

BUNDLES EXAMPLES

In order to accelerate as much as possible the prototyping of power converters, imperix provides several bundles including hardware, software and all the necessary accessories to start working as soon as products are delivered.
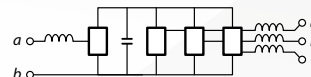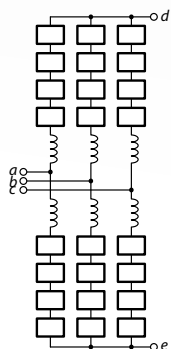
LIGHT MMC BUNDLE
REACH WORLD-CLASS RESULTS IN NO TIME!

The MMC bundle is a typical example of a ready-to-use system. Dedicated to Modular Multilevel Converters it allows engineers to focus on converter control techniques rather than hardware implementation.

* HARDWARE + SOFTWARE

- 3x B-Box RCP + ACG SDK
- 3x open chassis with 24 x PEH 2015
- 6x inductors
- Grid-side panel
- 4x voltage sensors
- 6x current sensors
- All needed cables

—————————————— OPTIONS ——————

- Without ACG SDK (Simulink™ blockset)

—————————————— VARIANTS ——————

- PEB4046 for increased power

MICROGRID BUNDLE
EXPERIMENT IN THE REAL WORLD!

The microgrid test bench is a multi-purpose test bench for power electronics. It is able to support both HIL simulation and low-voltage experimentation with an easy-to-use reconfigurable hardware.

* HARDWARE + SOFTWARE

- B-Box RCP + ACG SDK
- Interface for Opal-RT simulators
- Opal-RT OP4510
- PowerTrench with 6x PEB SiC 8024
- Passives filters box
- All needed cables

—————————————— OPTIONS ——————

- Without ACG SDK (Simulink™ blockset)
- Grid connection box
- Power amplifier for PHIL

—————————————— VARIANTS ——————

- Other configuration

* All current prices are available on www.imperix.com

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