OPAL-RT TECHNOLOGIES

OP1420
MICROGRID PHIL
TEST BENCH

WWW.OPAL-RT.COM

OP1420: Microgrid PHIL Test Bench

Quickly emulate grids, energy sources and DERs with a vertically integrated turnkey solution.

At institutions across the world, **Power Hardware-in-the-Loop (PHIL)** is being adopted by **power systems** and **power electronics** laboratories to improve the quality of **teaching** and **research**.

However, since PHIL can be a complex, time-consuming endeavor, OPAL-RT has created the OP1420, a **complete** and **vertically-integrated high-fidelity Power Hardware-in-the-Loop Test Bench** for all microgrid laboratories.

Read on to learn why the OP1420 is the **ideal** system for **emulating microgrids, DERs and/or energy sources** within your lab.

Note: Final product may differ in scale and appearance.

The OP1420 Advantage

Trustworthy

Made to ensure closed-loop stability, accuracy and high-bandwidth PHIL by a company with over 20 years of experience.

Turnkey

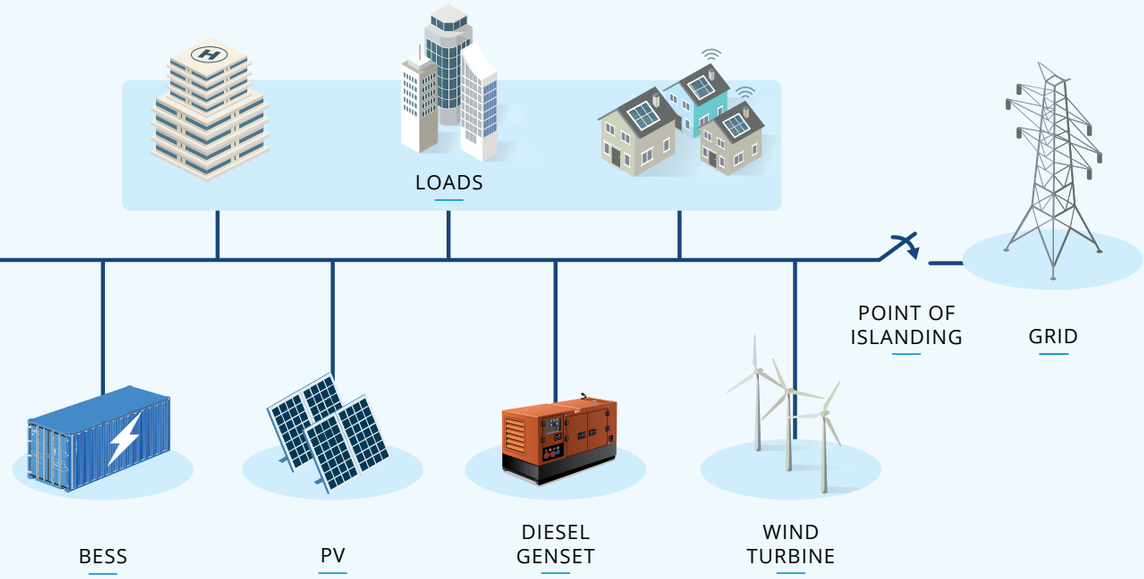
Save time and money with an intuitive, ready-to-use solution.

Safe

Features overload, short circuit and over temperature protection for enhanced safety.

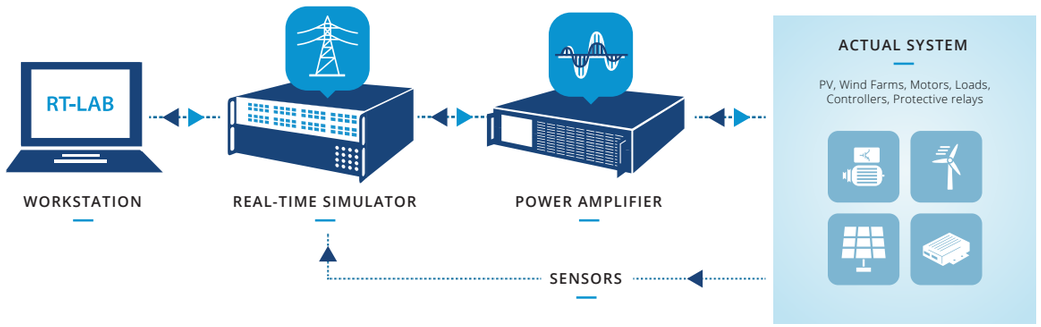
Microgrid Simulation Meets Power Lab

Bring microgrid models to real time and extend their power buses into the lab to connect and test real power devices. Don't know where to start? No problem. Each OP1420 comes with a validated generic microgrid model, including an emulated controller.



What is Power Hardware-in-the-Loop (PHIL)?

PHIL is an extension of Hardware-in-the-Loop (HIL) testing, in which the real-time simulation environment is capable of exchanging power with Devices-under-Test (DUTs). The DUTs are interfaced to the simulator using a power amplifier, which is controlled by the simulation. To learn more about PHIL, visit www.opal-rt.com/power-hardware-in-the-loop/ or **contact us to speak with an expert**.

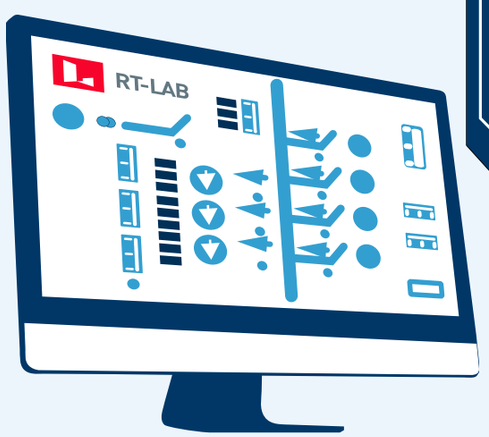


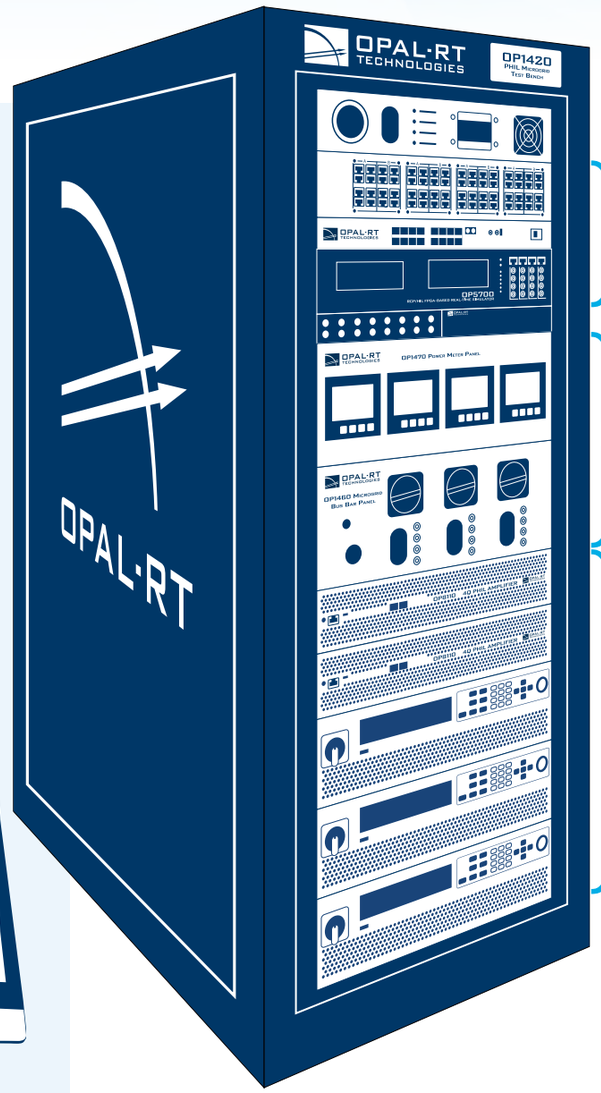
Everything You Need for Power Hardware-in-the-Loop

A quality Power Hardware-in-the-Loop setup requires components to be carefully selected for both their technical capability and intercompatibility.

SOFTWARE

Use RT-LAB software to bring complex microgrid models to life in your lab in just four easy steps. Not only does it feature ARTEMiS, the world's most powerful Real-Time solver for microgrids, RT-LAB also lets you change parameters on-the-fly, create dynamic visual interfaces, and automate tests with ease.



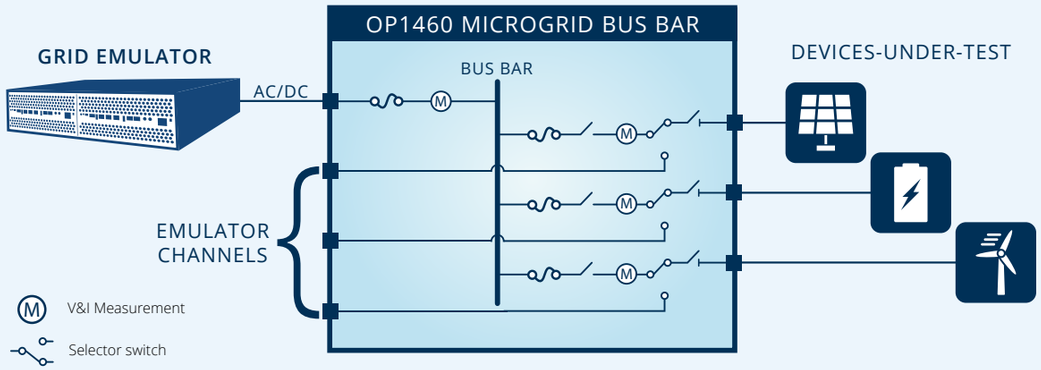


REAL-TIME SIMULATOR

The OP1420 comes with a Real-Time Simulator featuring a generic microgrid model with Simulink® and our ARTEMiS solver to help you get started as quickly as possible. Simulators contain multiple processors and a powerful FPGA capable of digitally simulating complex microgrids and power converter systems.

MICROGRID BUS BAR & POWER METER PANEL

With this novel product users can safely interface various equipment to a Power Hardware-in-the-Loop (PHIL) node created by an OP8110 used in Grid Emulation mode. Supports both single and three-phase (with neutral) interfacing via banana cables. In addition, it comes with an accurate power meter panel with integrated on-board LCD display that gives you real-time feedback of your simulation.



PHIL 4Q POWER AMPLIFIER

The Microgrid PHIL Test Bench comes with at least one three-phase, high-frequency 4-Quadrant Power Amplifier designed for Power Hardware-in-the-Loop applications involving grid, energy source and DER emulation. The Power Amplifiers connect directly to the Real-Time Simulator via optical link for low latency operation.

From Zero-to-PHIL in no Time

Our Proven Approach to HIL Extended to PHIL

Our mission has always been to make Hardware-in-the-Loop (HIL) as accessible as possible with very few steps. We've applied the same philosophy so you can bring your MATLAB®-Simulink® models to PHIL in four simple steps, just like when performing HIL!

RT-LAB

EDIT

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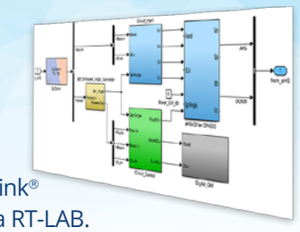


Open your Simulink® model directly via RT-LAB.

COMPILE

2 → {C} →

Transform your Simulink® model into a real-time application.

EXECUTE

3

Run the simulation on your real-time target using multiple cores.

INTERACT

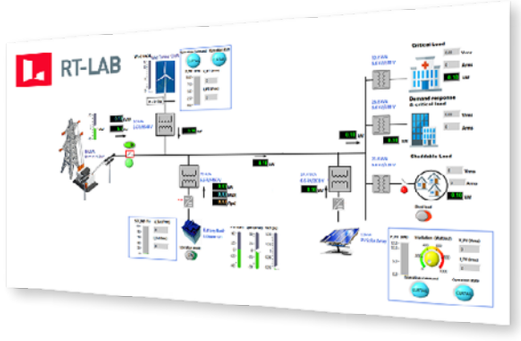
4

Use the graphical interface to change controls and acquire data.

Microgrid Model and ARTEMiS Solver Included

Power Hardware-in-the-Loop isn't just about hardware. It requires models and a specialized Real-Time Simulator. To help you get started faster, the OP1420 is shipped with a validated microgrid model built using the world's best Real-Time microgrid solver, ARTEMiS. The model even includes emulated controllers.

FPGA-based models are optionally available to reduce time step and latency to a very minimum, to further increase accuracy and stability.



A Power Amplifier Made for PHIL

The OP1420 comes with one to six 4Q PHIL Amplifiers to support a wide number of applications involving Grid, DER and/or Energy Source emulation. Use multiple Power Amplifiers to emulate one or more AC/DC Power Busses up to 30 kVA.

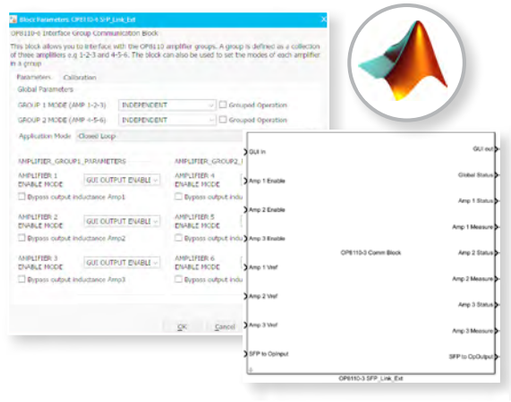
Key Features

The OP8110 is loaded with features making it the most high-performance and flexible 4Q Power Amplifier for PHIL applications on the market:

- ✓ Combine OP8110 Power Amplifiers to support up to 15 kW output
- ✓ Direct low-latency fiber-optic connection to OPAL-RT Simulators
- ✓ Large Signal Bandwidth: DC to 10 kHz (-3dB) & Low Harmonic Distortion
- ✓ Supports AC (1/3 Φ, up to 400 V_{L-L}) and DC (+/- 400 VDC) outputs with voltage and current modes
- ✓ 100% non-dissipative regeneration
- ✓ Embedded overload, short-circuit and over-temperature protection and coupling inductors with bypass relay
- ✓ Integrated voltage and current measurements connected directly to Simulink® and FPGA-based models.

Seamless Setup

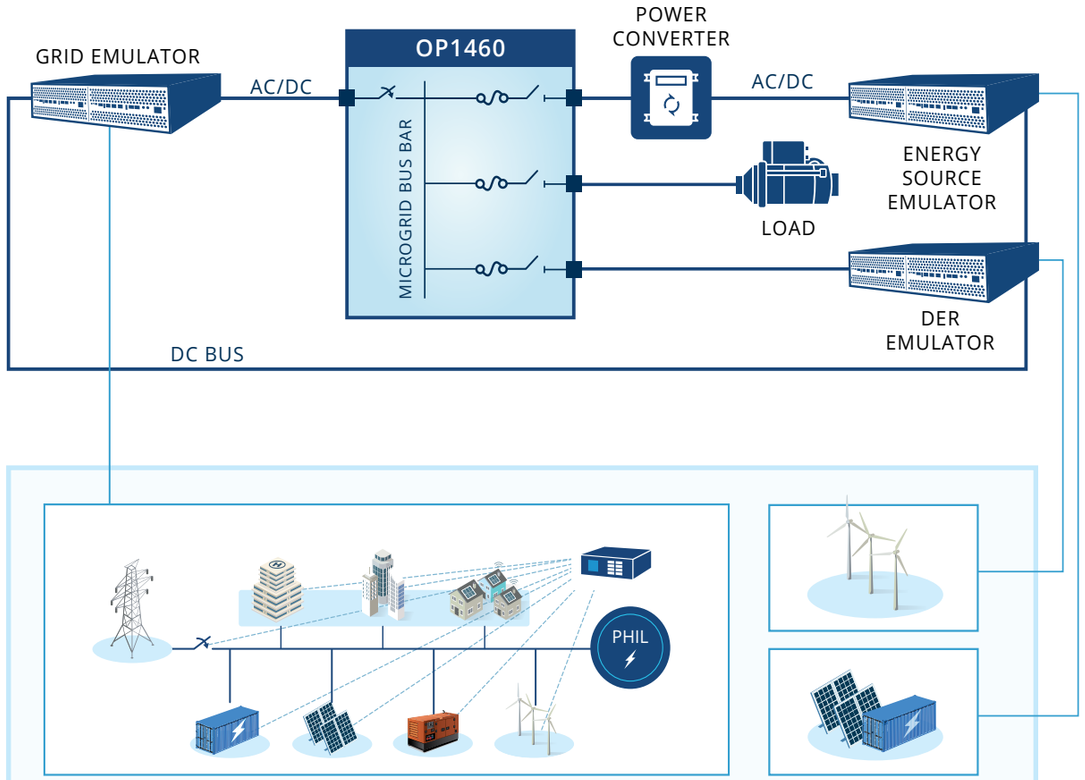
Power amplifier integration usually involves configuring the simulation environment to control and measure the PHIL setup. To streamline this process, we have developed a Simulink® block set for the configuration, communication and control of the OP8110 Power Amplifiers, as well as the OP1460 Microgrid Bus Bar.

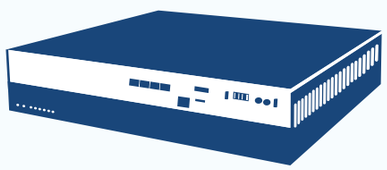


Bring the Power of Emulation into your Lab

Whether you are building a student lab, testing a single device (e.g., power converter) or creating complex research setup, the design of the Microgrid PHIL Test Bench makes setting up many applications a breeze. The below image shows the type of setups that can be achieved using multiple independent AC or DC emulator buses and the included microgrid bus bar. Power can even be recirculated between emulators via a common DC bus to reduce energy costs.

Want to learn more or have questions on specific applications with the OP1420? Reach out to us at **opal-rt.com/contact/.**





Real-Time Simulator

Use the Real-Time Simulator with our powerful ARTEMiS solvers or eHS FPGA to simulate microgrids, distributed energy resources (DER) and/or energy sources simultaneously to create multiple emulators in the PHIL environment. The Real-Time Simulator can even be used to control real equipment such as power converters and drives.

Plug-and-Play Student Labs

Building or upgrading your power systems lab? The OP1420 integrates directly with equipment from leading teaching laboratory providers to augment their teaching and research capabilities.

Lucas-Nuelle EPH-3 Trainer

Trusted by Academia

OPAL-RT is proud to have provided Real-Time Simulators to over 400 academic institutions internationally for their world-changing teaching and research laboratory activities.

OP1420 Selection Guide

Read this guide to help you select the **OP1420 configuration** that works best for your application(s). If you have any questions or require any additional help, please write us at opal-rt.com/contact/.

The OP1420 is offered in **4 standard configurations** with a set number of **5 kW PHIL Power Amplifiers (see Table B)**. **Power Amplifiers** can be interconnected to support higher AC and DC Bus power outputs of up to 30 kVA. Follow these steps to select the configuration that works best for you:

1. What are your bus requirements (type, voltage, power?) Note that you may have more than one bus with the OP1420 Test Bench.
2. Based on your requirements, from **Table A**, determine how many **Power Amplifiers** you require.*
3. From **Table B**, see which configurations correspond to the number **of Power Amplifiers** required.

Don't see the configuration you need? Contact us for more options.

Table A: Microgrid Bus Emulator Requirements

Bus Type and Voltage		Number of Power Amplifiers Required for Bus Output				
		Bus Power				
		5 kW	10 kW	15 kW	20 kW	30 kW
AC (3 Phase)	0-120 Vrms	1	2	3	4	6
	0-240 Vrms		3		6	
DC	+/- 400 VDC	1	3		6	

Table B: Standard OP1420 Configurations

Configuration Number	OP1420-10	OP1420-20	OP1420-30	OP1420-60
Available Emulator Channels (5 kW)	1	2	3	6
Total Nominal Power Available	5 kW	10 kW	15 kW	30 kW

**Note that if you require more than 6 channels then you may need more than one OP1420.*

OP1420 Configuration Example

If you require a **15 kW 0-120 Vrms AC bus**, then from **Table A**, three (3) Power Amplifiers are required. From **Table B**, there are two configurations **(OP1420-30, OP1420-60)** with three or more Power Amplifiers Available that can support this type of bus.

If you were to choose the **OP1420-60** configuration, then you would actually be able to support up to **two 15 kW 0-120 Vrms AC busses**, since it has six (6) Power Amplifiers.

Since bus types can be mixed and matched, the **OP1420-60** can also support **1 x 15 kW 0-120 Vrms AC bus** and **1 x 10kW +/- 400 VDC bus**. The same configuration could also be used for **3 x 10 kW 0-120 Vrms AC busses**.

OP8110 PHIL 4Q Power Amplifier Specifications

Electrical	
AC Voltage Range (AC mode)	0-120 Vrms (Ph-N) / 0-240 Vrms (Ph-Ph)
DC Voltage Range (DC mode)	+/- 400 VDC (Ph-Ph)
Current Range per phase	0-14 Arms
Current Peak per phase	20 Apk
Total Power per phase	1.7 kW

PHIL Performance	
Bandwidth (Hz)	DC to 10 kHz (-3db)
Absorption capacity	100%, power regeneration, no dissipation
Efficiency	90%
THD (3dB)	0.5% @ 0 - 1 kHz / 1% @ 1 kHz - 2 kHz / 2% @ 2 kHz - 10 kHz
Slew Rate	5V / µs, independent of the load
Time delay Input to output	5.5 µs to 8.3 µs
High Speed Communication Link	6.6 Gbps SFP Link, compatible with all OPAL-RT Simulators

Technical	
Control & command communication	Ethernet Port 10/100/1000
Hardware and software protection	Overload, short circuit, over temperature
Close loop measurement	Integrated Voltage and current measurements
Line emulation	Integrated coupling inductors
Close loop compensation	Extenal voltage measurement input
Cooling	Air forced
Mechanical specification	Low EMI, high-density, 2 µ 19" Rack Mount

ABOUT US

Founded in 1997, OPAL-RT TECHNOLOGIES is the leading developer of open real-time digital simulators and Hardware-In-the-Loop testing equipment for electrical, electro-mechanical and power electronic systems.

OPAL-RT simulators are used by engineers and researchers at leading manufacturer, utilities, universities and research centres around the world.

OPAL-RT's unique technological approach integrates parallel, distributed computing with commercial-off-the-shelf technologies.

The company's core software, RT-LAB, enables users to rapidly develop models suitable for real-time simulation, while minimalizing initial investment and their cost of ownership.

OPAL-RT also develops mathematical solvers and models specialized for accurate simulation of power electronics systems and electrical grid. RT-LAB and OPAL-RT solvers and models are integrated with advanced field programmable gate array (FPGA) I/O and processing boards to create complete solutions for RCP and HIL Testing.

OPAL-RT TECHNOLOGIES

OPAL-RT CORPORATE HEADQUARTERS
1751 Richardson, Suite 2525 | Montréal, Québec, Canada | H3K 1G6
Tel: 514-935-2323 | Toll free: 1-877-935-2323 | Fax: 514-935-4994

U.S.A.
OPAL-RT Corporation
2532 Harte Dr
Brighton, MI
48114, USA
Phone: 734-418-2961
Toll free: 1-877-935-2323

EUROPE
OPAL-RT Europe S.A.
196 Houdan Street
Sceaux, Hauts-de-Seine
92330, France
Tel: +33 1 75 60 24 89

GERMANY
OPAL-RT GERMANY GMBH
Bucher Str. 100, 90408
Nürnberg, Germany
Tel: +49-911-38445352

INTELLIGENT TRANSPORTATION SYSTEMS
OPAL-RT Intelligent Transportation Systems
10 Vivier Merle boulevard
Lyon, France, 69393
Tel: +33 67 60 80 36 08

INDIA
OPAL-RT Technologies India Pvt. Ltd.
648/A-4/5, 2nd Floor,
OM Chambers,
100 Foot Road
Indiranagar 1st Stage
Bangalore, Karnataka
560038, India
Tel: 080-25200305
Fax: 080-25200105

WWW.OPAL-RT.COM