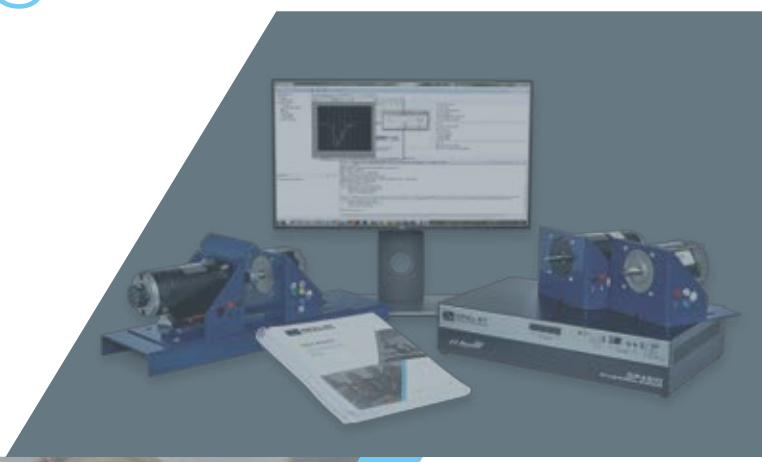
OPAL-RT TECHNOLOGIES

ACADEMIC OFFER

FOR UNIVERSITIES & COLLEGES



WWW.OPAL-RT.COM

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Teaching The Future

REAL-TIME SIMULATION IS ENABLING THE WORLD'S VISIONARIES TO MAKE INNOVATIVE IDEAS A REALITY

Jean Bélanger, Co-Founder, CEO and CTO of OPAL-RT TECHNOLOGIES

We are working hard toward our vision of providing accurate and affordable simulators so that imagination will be the only real limit to complex system design. Real-time simulation is indispensable for engineer-designers. Our mission is to make it accessible to all and democratize real-time simulation.

It is no coincidence that OPAL-RT's real-time simulation systems are currently used in nearly half of the world's universities with an electrical engineering department. More than 400 universities benefit from the most innovative technology on the market, with easily scalable equipment that can be reused for multiple projects.

Thanks to over 20 years' experience in HIL and our affordable and durable products, OPAL-RT is the trusted partner of professors, researchers and students around the world.

The Latest Technology to Improve Your Classes

WHY USE OPAL-RT TEACHING SOLUTIONS?

Similarity to Industrial Environment

OPAL-RT's laboratories allow students to be up to date with the most modern industrial working techniques

Interactivity and Versatility

OPAL-RT's laboratory modules include hands-on exercises, allow students to design and test their concepts, and save time in the validation of their projects

Lower Maintenance Time and Cost

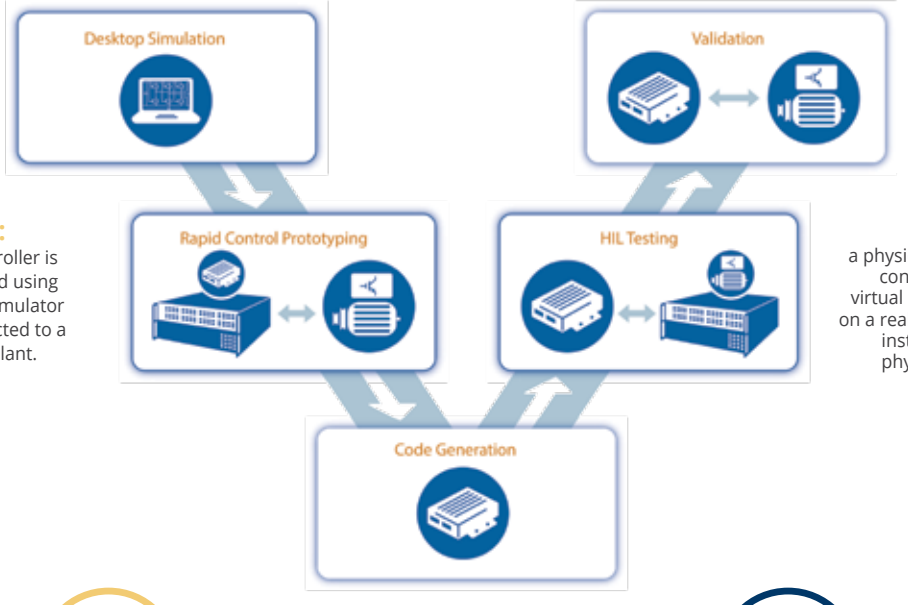
Universities that adopt OPAL-RT's laboratories reduce the amount of analog lab equipment needed resulting in lower maintenance time and cost

San Jose State University, California, United States

Products Offer

YOUR PROJECT, OUR BUNDLES

Inspired by the industry, HIL and RCP approaches make it possible to test, validate and reduce controller development time in a secure environment. Our tailored solutions enable you to fully teach the V-cycle principles used in the industry. Students and researchers can build a model, then validate the same model against a real system.



RCP:
a plant controller is implemented using a real-time simulator and is connected to a physical plant.

HIL:
a physical controller is connected to a virtual plant executed on a real-time simulator, instead of to a physical plant.

RCP **BUNDLES** HIL

RT-LAB | OP4200 small all-purpose RCP/ HIL system
BDL42-100

RT-LAB | OP4510 power electronics RCP/ HIL system
BDL45-100

eHS32 Solver | OP4200 introductory power electronics HIL simulator
BDL42-300

eHS32 Solver | OP4510 power electronics HIL simulator
BDL45-300

HYPERSIM |OP4510 protection HIL system
BDL45-411

eMEGASIM |OP4510 protection HIL system
BDL45-410

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RT-LAB | OP4200

Small all-purpose rapid control prototyping (RCP) system

BDL42-100

AFFORDABLE ENTRY-LEVEL SOLUTION FOR YOUR RCP/HIL NEEDS

Dimensions: 11.2 “(W) x 8.7 “(D) x 9,75” (H)

HIGHLIGHTS

- Unsurpassed connectivity including CAN bus and SFP optical interfacing to meet various industry needs.
- High-precision PWM capture and generation, and other timed signals (Encoder, Resolver, Hall Effect).

DESCRIPTION

The OP4200 RCP system offers Rapid Control Prototyping (RCP), data acquisition and I/O expansion capabilities in a desktop-friendly package combined with RT-LAB software. Create more advanced FPGA RCP applications by adding the RT-XSG toolbox for FPGA real-time simulation.

PURPOSE

Quickly move from your MATLAB/ Simulink® designed control systems into real time with RT-LAB, our platform for powering your innovative industrial and research RCP tests and validation.

APPLICATIONS

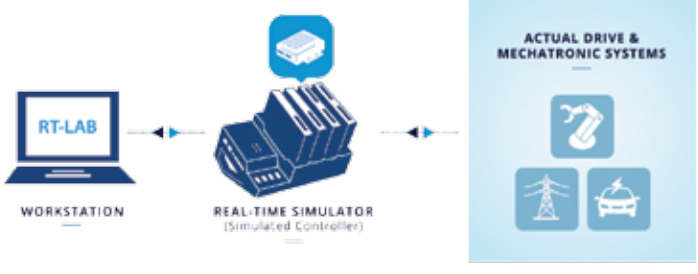
Combustion engine control, robotics, battery management system emulation, Uninterruptible Power Supply (UPS) control, motor drive controller, microgrid agent control, classroom experiments, workshops and more.

KEY PERFORMANCE SPECS

- Outer control loop frequency (CPU): < 10 kHz
- Fast control loop frequency (FPGA): < 1 MHz (option)
- Advanced PWM generation: up to 200 kHz, resolution 5 ns

TYPICAL USE CASE

RCP Process



System Configuration	Baseline
HARDWARE	
OP4200 Simulator ARM® Cortex® A9 CPU - 2 cores - 1 GHz, Xilinx Zynq® FPGA Kintex™7 125K LUT Connectivity - Ethernet port 10/100/1000 Mbps (RJ45). RS232 (DB9), USB2.0, 5-Gbit/s high-speed fiber optic link (2x SFP)	✓
Digital input | 32 channels, 4.5V to 50V, 40 ns typical propagation delay	***
Digital output | 32 channels, 5V to 30V, 65 ns typical propagation delay	***
Analog input | 16 channels, 16 bits, 500 kS/s, +/-20V, adjustable range	***
Analog output | 16 channels, 16bits, 1 MS/s, +/-16V	***
Analog input | 16 channels, 16 bits, 2MS/s, +/-20V	***
Timed generation and measurement firmware | Selectable 32 timed digital inputs and 32 timed digital outputs for OP4200	***
SOFTWARE	
RT-LAB | Real-time Simulation Software	✓
RT-XSG | RT-XSG toolbox for FPGA real-time simulation	***
COMMUNICATION PROTOCOLS	
CAN bus interface board	***
SFP | RS-232 | optical synchronization link | USB | JTAG | RJ45 Ethernet port	✓

*** Optional

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RT-LAB | OP4510

Power electronics rapid control prototyping (RCP) system

BDL45-100

SPECIALIZED POWER ELECTRONICS RCP/HIL SIMULATOR

Dimensions: 17" (W) x 10.8" (D) x 3.5" (H)

HIGHLIGHTS

- Optimal power/speed ratio with a powerful combination of CPU/FPGA.
- Fast optimized I/O and a comprehensive library for power electronics applications.
- High precision three-phase PWM capture and generation, and other timed signals (Encoder, Resolver, Hall Effect).

DESCRIPTION

The OP4510 RCP system offers Rapid Control Prototyping (RCP), and provides advanced control systems features compatible with widely-used communication protocols. With this solution, you can bring your power electronics control design testing to the next level.

PURPOSE

Equipped with the latest generation of Intel Xeon four-core processors and a powerful Xilinx Kintex 7 FPGA, the OP4510 delivers raw simulation power for both CPU-based real-time simulation and sub-microsecond time step power electronics simulation. This system delivers the fastest and the most versatile RCP application for power electronics.

APPLICATIONS

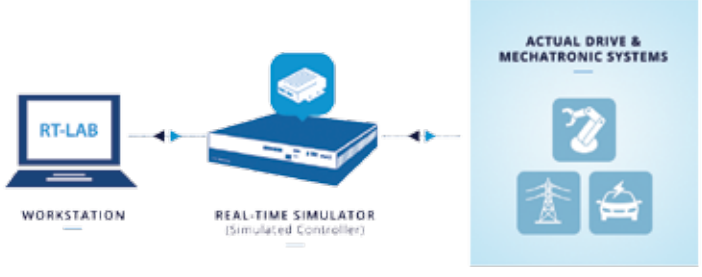
Converter and inverter control, motor drive control, microgrid agent control, generator control, multidrive systems control, Modular Multilevel Converters (MMC) control, power electronics classroom experiments and more.

KEY PERFORMANCE SPECS

- Outer Control Loop Frequency (CPU): < 100 kHz
- Fast control loop Frequency (FPGA): 500 kHz to 10 MHz depending on user code implementation and complexity (the base frequency of the FPGA is 200 MHz)
- Advanced PWM generation: up to 200 kHz, resolution 5 ns

TYPICAL USE CASE

RCP Process



System Configuration	Baseline
HARDWARE	
OP4510 Simulator Intel Xeon CPU - 4 cores - 3.5 GHz, Xilinx FPGA Kintex™-7 325T Connectivity - Ethernet port 10/100/1000 Mbps (2x RJ45). RS232 (DB9), USB2.0, 5-Gbit/s high-speed fiber optic link (4x SFP)	✓
Digital input | 32 channels, 4.5V to 50V, 40 ns high-speed digital I/O	***
Digital output | 32 channels, 5V to 30V, 200 ns to 65 ns	***
Analog input | 16 channels, 16 bits, 500 kS/s, +-20V	***
Analog output | 16 channels, 16 bits, 1MS/s, +-16V	***
Analog input | 16 channels, 2MS/s, 16bits, +-20V	***
Timed generation and measurement firmware | Selectable 32 timed digital inputs and 32 timed digital outputs	***
RS422 Adapter	***
SOFTWARE	
RT-LAB | Real-time simulation software	✓
RT-XSG | RT-XSG toolbox for FPGA real-time simulation	***
COMMUNICATION PROTOCOLS	
CAN bus interface board	***

*** Optional

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eHS32 Solver | OP4200

Introductory power electronics HIL simulator

BDL42-300

POWER ELECTRONICS HIL PERFORMANCE AT A GAME-CHANGING PRICE

Dimensions: 11.2 "(W) x 8.7 "(D) x 9,75" (H)

HIGHLIGHTS

- Convenient eHS user interface to import real-time electrical models from MATLAB/Simulink®, PLECS®, PSIM® or NI MULTISIM®.
- Speed and accuracy with a minimum model time step of 100 microseconds (CPU) or 125 nanoseconds (FPGA).
- Simulate up to 48 switches on one FPGA core without decoupling your power electronics schematics.

DESCRIPTION

Powered by the renowned eHS electrical solver, the OP4200 HIL system delivers the essential features you need to kick off your power electronics project. With this modular solution, you can quickly compile and execute your electronic schematics, reconfigure I/Os, including signal format and conditioning, to fit your immediate needs.

PURPOSE

Quickly move from your power electronics schematics (designed with MATLAB/Simulink®, PLECS®, PSIM® or NI MULTISIM®) into the real-time RT-LAB platform to run your most innovative HIL tests and validations.

APPLICATIONS

Battery management system and battery simulation, data acquisition for analog and digital signals, microgrid and renewable (detailed low latency model), power electronics converters (up to 48 switches), programmable analog and digital signal generators.

KEY PERFORMANCE SPECS

- Switching Frequency: up to 200 KHZ
- Model minimum time step: 100 µs (CPU), 125 ns (FPGA)
- Control loop minimum delay: 1.5 µs
- Number of power electronics switches: 48 switches on 1 FPGA

TYPICAL USE CASE

HIL Process

System Configuration

	Baseline
HARDWARE	
OP4200 Simulator ARM® Cortex® A9 CPU - 2 cores - 1 GHz, Xilinx Zynq® FPGA Kintex™7 125K LUT Connectivity - Ethernet port 10/100/1000 Mbps (RJ45). RS232 (DB9), USB2.0, 5-Gbit/s high-speed fiber optic link (2x SFP)	✓
Digital input | 32 channels, 4.5V to 50V, 40 ns typical propagation delay	***
Digital output | 32 channels, 5V to 30V, 65 ns typical propagation delay	***
Analog input | 16 channels, 16 bits, 500 kS/s, +/-20V, adjustable range	***
Analog output | 16 channels, 16bits, 1 MS/s, +/-16V	***
Analog input | 16 channels, 16 bits, 2MS/s, +/-20V	***
Timed generation and measurement firmware | Selectable 32 timed digital inputs and 32 timed digital outputs	***
SOFTWARE	
RT-LAB | Real-time simulation software	✓
eHS32 power electronic solver provides 48 coupled switches	✓
RT-XSG | RT-XSG toolbox for FPGA real-time simulation	***
COMMUNICATION PROTOCOLS	
CAN bus interface board	***

*** Optional

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eHS32 Solver | OP4510

Power electronics HIL simulator

BDL45-300

COMPLETE AND FLEXIBLE SOLUTION FOR YOUR HIL SIMULATION NEEDS

Dimensions: 17” (W) x 10.8” (D) x 3.5” (H)

HIGHLIGHTS

- Optimal power/speed ratio with a powerful combination of CPU/FPGA.
- Fast optimized I/O and a comprehensive library for power electronics applications.
- High precision three-phase PWM capture and generation, and other timed signals (Encoder, Resolver, Hall Effect).

DESCRIPTION

Powered by our renowned eHS electrical solver, the OP4510 HIL system offers the best performance at an affordable price. Equipped with four core processors and FPGA, it delivers a scalable solution for your power electronics simulations.

PURPOSE

Evolve from introductory to advanced model simulations using power electronics schematics (designed with MATLAB/Simulink®, PLECS®, PSIM® or NI MULTISIM®) in RT-LAB to run your most innovative HIL tests and validations.

APPLICATIONS

Battery management system and battery simulation, power electronics converters, electric motors, power grid connected HIL simulation, supervisory control and data acquisition systems, high-level control and low-level control for microgrid, renewable, sun, wind, battery, energy storage and other.

KEY PERFORMANCE SPECS

- Switching Frequency - up to 200 KHZ
- Control loop minimum delay - 1.5 µs
- Model minimum time step - 3 µs (CPU), 125 ns (FPGA)
- Number of electrical motors on FPGA – 2 motors
- Number of power electronics switches: 48 switches on 1 FPGA

TYPICAL USE CASE

HIL Process

System Configuration

System Configuration	Baseline
HARDWARE	
OP4510 Simulator Intel Xeon CPU - 4 cores - 3.5 GHz, Xilinx FPGA Kintex®-7 325T Connectivity - Ethernet port 10/100/1000 Mbps (2x RJ45). RS232 (DB9), USB2.0, 5-Gbit/s high-speed fiber optic link (4x SFP)	✓
Digital input | 32 channels, 4.5V to 50V, 40 ns high-speed digital I/O	***
Digital output | 32 channels, 5V to 30V, 200 ns to 65 ns	***
Analog input | 16 channels, 16 bits, 500 kS/s, +-20V	***
Analog output | 16 channels, 16 bits, 1MS/s, +-16V	***
Analog input | 16 channels, 2MS/s, 16bits, +-20V	***
Timed generation and measurement firmware | Selectable 32 timed digital inputs and 32 timed digital outputs	***
RS422 Adapter	***
SOFTWARE	
RT-LAB | Real-time simulation software	✓
eHS32 power electronics solver provides 48 coupled switches	✓
RT-XSG | RT-XSG toolbox for FPGA real-time simulation	***
COMMUNICATION PROTOCOLS	
CAN bus interface board	***

*** Optional

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HYPERSIM® | OP4510

Comprehensive power grid simulator and protection system HIL testing for research and education

BDL45-411

DESIGNED BY POWER SYSTEM ENGINEERS, FOR POWER SYSTEM ENGINEERS

Dimensions: 17" (W) x 10.8" (D) x 3.5" (H)

HIGHLIGHTS

- One-line diagram schematic editor.
- Suitable for network tests with up to 30 single-phase nodes and 10 three-phase buses.
- Specialized test automation tool for protection.

DESCRIPTION

Provide large and complex model-based or basic functional test scenarios, while simultaneously supporting an array of inputs and outputs for unsurpassed connectivity. This solution provides advanced real-time monitoring, control, and protection capabilities.

PURPOSE

This solution tests your protection control relay using HYPERSIM models in closed loop for detailed EMT simulation. It also lets you see the behavior of the grid based on the relay under test in real-time.

APPLICATIONS

Protection function testing via analog and digital interfaces or IEC61850 sampled value and GOOSE, protection scheme testing (including virtual relay library), events analysis.

KEY PERFORMANCE SPECS

- Control loop minimum delay: 5 µs
- Model minimum time step: 3 µs
- Run offline simulations
- Maximum entry-level network size: 30 single-phase nodes on 1 core
- COMTRADE playback

TYPICAL USE CASE

HIL Process

System Configuration	Baseline
HARDWARE	
OP4510 Simulator Intel Xeon CPU - 4 cores - 3.5 GHz, Xilinx FPGA Kintex™-7 325T Connectivity - Ethernet port 10/100/1000 Mbps (2x RJ45), RS232 (DB9), USB2.0, 5-Gbit/s high-speed fiber optic link (4x SFP)	✓
Digital input | 32 channels, 4.5V to 50V, 40 ns high-speed digital I/O	***
Digital output | 32 channels, 5V to 30V, 200 ns to 65 ns	***
Analog input | 16 channels, 16 bits, 500 kS/s, +-20V	***
Analog output | 16 channels, 16 bits, 1MS/s, +-16V	***
Timed generation and measurement firmware | Selectable 32 timed digital inputs and 32 timed digital outputs	***
Dual-port Gigabit Ethernet interface card	
Time synchronization card, GPS, IEEE 1588, 1PPS, IRIG-B	***
SOFTWARE	
HYPERSIM Editor | Windows-based model editing software	✓
HYPERSIM HX30 | Real-time simulation of up to 30 nodes (10 x 3-phase buses)	✓
ScopeView for HYPERSIM HX30 | Waveform visualization and analysis software	✓
TestView for HYPERSIM HX30 | HYPERSIM® Test automation tool	***
TestView Function 121 | TestView test sequence add-on for distance protection relay (IEC 60255-100)	***
COMMUNICATION PROTOCOLS	
IEC 61850-8-1 GOOSE/Sampled Values/SV data integrity manipulation C37.118 slave/master DNP3 slave/master Modbus slave/master	***

*** Optional

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eMEGASIM | OP4510

Closed loop protection relay testing

BDL45-410

OPEN AND FLEXIBLE HIL SOLUTION FOR PROTECTION RELAYS BASED ON MATLAB/ SIMULINK®

Dimensions: 17" (W) x 10.8" (D) x 3.5" (H)

HIGHLIGHTS

- Optimize the real-time performance of Simscape Power System (SPS) with ARTEMiS SSN, a specialized power system solver.
- Unprecedented speed and accuracy with a minimum model time step of 3 microseconds.
- Suitable for network tests with up to 75 states (approx. 90 single-phase nodes on 1 core).

DESCRIPTION

Driven by eMEGASIM, the OP4510 Protection HIL System is designed for R&D testing as well as validation of new protection algorithms. The OP4510 can be upgraded to the latest communication protocols (such as IEC 61850 Goose and SV), and can easily be combined with an amplifier for a wider range of tests.

PURPOSE

This solution lets you run your Simscape Power Systems™ models in closed loop for detailed EMT simulation feedback. Monitor the behavior of the grid, based on the relay under test, with a selection of industry communication protocols.

APPLICATIONS

Protection function testing via analog and digital interfaces or IEC61850 sampled value and GOOSE, protection scheme testing (including virtual relay library), events analysis.

KEY PERFORMANCE SPECS

- Maximum entry-level network size - 75 states (approx. 90 single-phase nodes on 1 core)
- Control loop minimum delay - 7 µs
- Minimum model time step - 3 µs

TYPICAL USE CASE

HIL Process

System Configuration	Baseline
HARDWARE	
OP4510 Simulator Intel Xeon CPU - 4 cores - 3.5 GHz, Xilinx FPGA Kintex™-7 325T Connectivity - Ethernet port 10/100/1000 Mbps (2x RJ45). RS232 (DB9), USB2.0, 5-Gbit/s high-speed fiber optic link (4x SFP)	✓
Digital input | 32 channels, 4.5V to 50V, 40 ns high-speed digital I/O	***
Digital output | 32 channels, 5 V to 30 V, 200 ns to 65 ns	***
Analog input | 16 channels, 16 bits, 500 kS/s, +-20V	***
Analog output | 16 channels, 16 bits, 1MS/s, +-16V	***
Timed generation and measurement firmware | Selectable 32 timed digital inputs and 32 timed digital outputs	***
Dual-port Gigabit Ethernet interface board	
Time synchronization board, GPS, IEEE 1588, 1PPS, IRIG-B	***
SOFTWARE	
RT-LAB | Real-time simulation software	✓
eMEGASIM FX75 | Real-time simulation of up to 75 states (sum of capacitors and inductors)	✓
ScopeView | Waveform visualization and analysis software	***
Communication Protocols	
IEC 61850-8-1 GOOSE/Sampled Values/SV data integrity manipulation C37.118 slave/master DNP3 slave/master Modbus slave/master	***

*** Optional

Teaching Laboratory Kits

OUR ACADEMIC TEACHING LABORATORY KITS TAILORED FOR TODAY'S TEACHERS NEEDS

Based on years of research and experience in power electronics and power system, and listening to the users needs, OPAL-RT developed Hardware-in-the-Loop (HIL) and Rapid Control Prototyping (RCP) Teaching Laboratories for universities to teach in an efficient, reliable and affordable way.

2 TYPES OF TEACHING LABORATORY KITS

Courseware kits

Test bench

Teaching Laboratory Kits

COURSEWARE KITS

PRODUCTS

KIT NUMBER	SUBJECTS
OP1160	Electric machines
OP1130	Power electronics
OP1140	Power System (PS)

TEST BENCHES

PRODUCTS

TB NUMBER	SUBJECTS
OP1300	Power electronics
OP1640	Drivelab Kit
OP1600 OP1620	Simulation Systems for Electric Motors

* All of our courseware kits come in two versions: Development and Run-Time

DEFINITION

Run-Time: Allow to run any courseware or any model developed with the development version

Development: Allow to develop models, compile and run your models

IN THE CLASSROOM

Development Simulator for the teacher

Run-Time for the students

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Electric machines teaching laboratory

Courseware

OP1160

"This courseware helps to master synchronous and asynchronous machines, from parameter identification to full operation in generator and motor modes."

Danielle Nasrallah, P.Eng, Ph.D
Technical Lead in Advanced Control and Electric Drives

The electric machines teaching laboratory constitutes a fundamental learning tool to thoroughly understand synchronous and asynchronous machines.

Students are in-the-loop, interacting with virtual machines and doing experiments as they woud with physical test benches. As a result, they will fully grasp steady-state model parameter identification, synchronous machine motor operations and asynchronous machine speed control.

MAIN BENEFITS

- An interactive user interface brings the students into the loop and allows them to perform step-by-step experiments.
- Avoid costly damage or significant impact that could be caused by errors, such as overspeeding.
- Protection is implemented and allows students to reset the experiment, making it possible to recover from mistakes.

COURSEWARE KIT

COURSEWARE

Electric machines teaching laboratory
10 Modules

OPAL-RT OP4510

- 4-core CPU, Xeon E3 3.5 GHz
- Kintex-7 XILINX FPGA, 325T
- 32 Di, 32Do, 16 Ai, 16Ao

OUR ELECTRIC MACHINE TEACHING LABORATORY COMES IN TWO SECTIONS WITH FIVE MODULES EACH

SYNCHRONOUS MACHINE

OBJECTIVES

- Learn the principles of operation of synchronous machines.
- Identify steady-state model parameters.
- Understand dynamics, stability and power flow control.

MODULE 1:
Parameters Identification

Laboratory Exercises include:

Experimental parameter identification for the steady state synchronous machine model.

MODULE 2:
Generator Mode-Passive Load

Laboratory Exercises include:

Synchronous generator feeding a variable passive load, without being connected to the grid.

MODULE 3:
Generator Mode-Grid Connection

Laboratory Exercises include:

Synchronous generator connected to the grid: power flow analysis and stability limits.

MODULE 4:
Motor Mode

Laboratory Exercises include:

Synchronous motor coupled to a DC generator feeding a variable resistor, thus achieving variable torque on motor shaft.

MODULE 5:
Faults & Recovery

Laboratory Exercises include:

Three-phase short-circuit test and recovery of the synchronous machine voltages after clearing fault.

ASYNCHRONOUS MACHINE

OBJECTIVES

- Learn the principles of operation of asynchronous machines.
- Identify steady-state model parameters.
- Apply various procedures for speed control.

MODULE 1:
Transformer & Frequency Converter

Laboratory Exercises include:

Wound-rotor asynchronous machine operating as a phase shifter transformer and frequency converter.

MODULE 2:
Parameters Identification

Laboratory Exercises include:

Experimental parameter identification for the steady state asynchronous machine model.

MODULE 3:
Speed Control-Variable Voltage

Laboratory Exercises include:
Speed control of the asynchronous motor using variable voltage and fixed frequency.

MODULE 4:
Speed Control-Variable Resistance

Laboratory Exercises include:

Speed control of the wound-rotor asynchronous motor using variable rotor resistance.

MODULE 5:
Speed Control-Three-Phase Inverter

Laboratory Exercises include:

Speed control of the asynchronous motor using a three-phase inverter with variable voltage and frequency.

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Power electronics HIL teaching laboratory

Courseware

OP1130

"All power electronics models used in the teaching courseware run on FPGA for very high-definition accuracy. Students can discover and learn power electronics with very high definition tools that are fast enough to visualize all phenomena that can be seen on more expensive and time-consuming analog setups."

Pierre-Yves Robert, M.Sc.A
FPGA Specialist

Power electronics HIL teaching laboratory by OPAL-RT TECHNOLOGIES is an educational courseware intended to teach power electronics to university undergraduate students. Students can experiment and learn power electronics, such as converters, rectifiers, and inverters, including the control logic with HIL and RCP Tools commonly used in innovative power electronics industry research and development.

MAIN BENEFITS

- Less analog lab equipment is needed, with subsequent lower maintenance time and cost.
- Editable and upgradable courseware to fit with specific courses or activities.
- Provides a good platform to pursue graduate research on the same setup.

COURSEWARE KIT

COURSEWARE

Power electronics HIL teaching laboratory Modules 1 to 4

OPAL-RT OP4510

- 4-core CPU, Xeon E3 3.5 GHz
- Kintex-7 XILINX FPGA, 325T
- 32 Di, 32Do, 16 Ai, 16Ao

Also available on these platforms:

OPAL-RT OP4200

- ARM® Cortex® A9 CPU - 2 cores - 1 GHz
- Xilinx Zynq® FPGA Kintex™7 125K LUT
- 32 Di, 32Do, 16 Ai, 16Ao

NI cRIO-9068

- 667 MHz dual-core ARM Cortex-A9 processor
- Zynq-7020 FPGA
- 8-slot chassis.

OUR POWER ELECTRONICS HIL TEACHING LABORATORY COMES WITH FOUR MODULES

Power electronics software provides real-time simulation of DC-DC, AC-DC and DC-AC converters for educational purposes in power electronics laboratories. The teaching laboratory is divided into four modules. All power electronics modules include laboratory exercises.

MODULE 1 :

DC-DC Choppers

OBJECTIVES

- Learn the principles of operation of choppers: boost, buck, buck-boost.
- Understand the impact of duty cycle value on the converter in continuous conduction mode

Laboratory Exercises include:

- Impact of varying parameters of converter
- Effect of varying the duty cycle
- Calculation of PI controller parameters using MyRio E

MODULE 2 :

AC-DC Rectifiers

OBJECTIVES

- Learn the principles of operation of passive rectifiers
- Understand single-phase and three-phase diode bridges.

Laboratory Exercises include:

- Impact of varying rectifier parameters
- Calculation of the form factor and the ripple factor
- Impact of activation of smoothing capacitor

MODULE 3 :

DC-AC Inverters

OBJECTIVES

- Learn the principles of operation of three-phase two-level inverter and PWM modulation technique
- Study the effect of the neutral connection on waveforms of the phase voltages and line currents
- Study the effect of filtering at the inverter output

Laboratory Exercises include:

- Impact of neutral connection and filtering
- Impact of varying PWM frequency and dead time
- Introduction to the hysteresis controller using MyRio external controller

MODULE 4 :

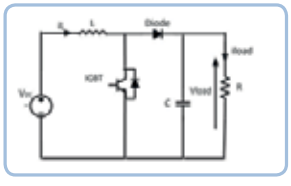
Three-Phase Three-Level NPC Inverter/ Rectifier

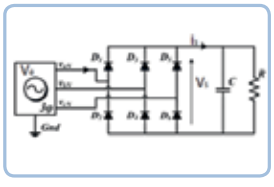
OBJECTIVES

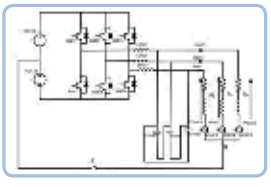
- Learn the principles of operation of three-phase three-level NPC topology
- Operate in inverter and rectifier modes
- Study the effect of filtering at the converter output

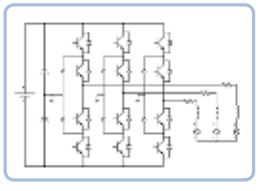
Laboratory Exercises include:

- Design aspects: component sizing /switch control
- Variable-configuration load: AC-motor/capacitive/ inductive
- Power flow/waveforms









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Power System (PS) teaching laboratory

Courseware

OP1140

"Learning the basis of power systems using HIL helped me be prepared for industrial challenges."

François Berthelot
Business Unit Manager – Eastern North America
Sales Engineer

The Power System (PS) teaching laboratory is intended to perform transient stability analysis of electric grids. The basic power grid example, covered in all fundamental electric grids courses, is analyzed in time-domain and phasor-domain.

As learning outcomes, students will understand concepts of infinite source, synchronous alternator (with or without damper windings), transformers, buses, faults and power system stabilizers.

MAIN BENEFITS

- Learn power systems stability concepts and interact in realtime in a safe environment.
- Interact with an intuitive and versatile graphical user interface (GUI) for all modules.
- Visualize the impact of faults and stabilize the system using power systems stabilizers.

The grid is composed of an infinite source connected to a synchronous alternator via one transformer and three buses. The alternator can be equipped with rotor damper windings. A power system stabilizer is available and can be triggered according to the tests that are running.

COURSEWARE

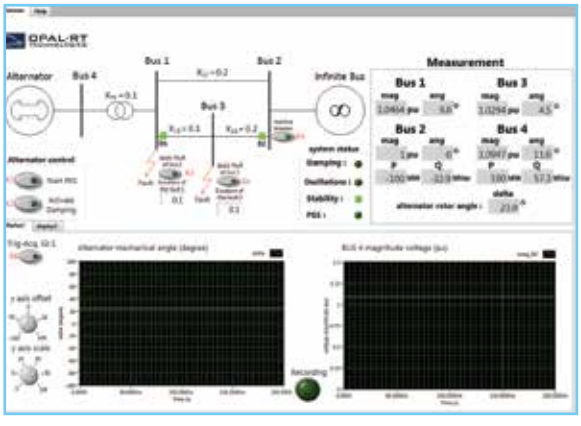
COURSEWARE

Power System (PS) teaching laboratory Modules 1 to 3

OPAL-RT OP4510

- 4-core CPU, Xeon E3 3.5 GHz
- Kintex-7 XILINX FPGA, 325T
- 32 Di, 32Do, 16 Ai, 16Ao

OUR POWER SYSTEM (PS) TEACHING LABORATORY COMES WITH THREE MODULES



OBJECTIVES

- Analyze transient stability of power systems in time-domain and phasor-domain.
- Visualize the power flow of the system.
- Use the intuitive Graphical User Interface (GUI) to apply faults on buses and observe the impacts on key signals.
- Activate the alternator rotor's dampers and understand their effect.
- Start the power system stabilizer to recover from faults.

MODULE 1:
Power Flow w/o Faults
Laboratory Exercises include:

Analyse, measure and validate the power flow of the system due to a three phase short-circuit occurring on bus 1.

MODULE 2:
Damper Windings
Laboratory Exercises include:

Same as in module 1, plus the alternator rotor is equipped with damper windings.

MODULE 3:
Faults & Recovery
Laboratory Exercises include:

Transient stability analysis of the system due to a three phase short-circuit occurring on bus 3.

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Power electronics

Test bench

OP1300

"Accelerate your development by going into the lab early to challenge your control in a real world environment."

Syed Qaseem Ali , Ph.D
Team Leader - Transmission, Distribution and Distributed Energy Resources Application eXpertise and Electrical Simulation division (AXES)

Modular, flexible and configurable, the power electronics test bench combines a state-of-the-art Hardware-in-the-Loop (HIL) simulator from OPAL-RT with Imperix's Rapid Control Prototyping (RCP) system and real power hardware. It enables rapid development of power electronics, drives and smart grid applications across industry and academia.

PLATFORM OFFER FOR POWER ELECTRONICS TEST BENCH

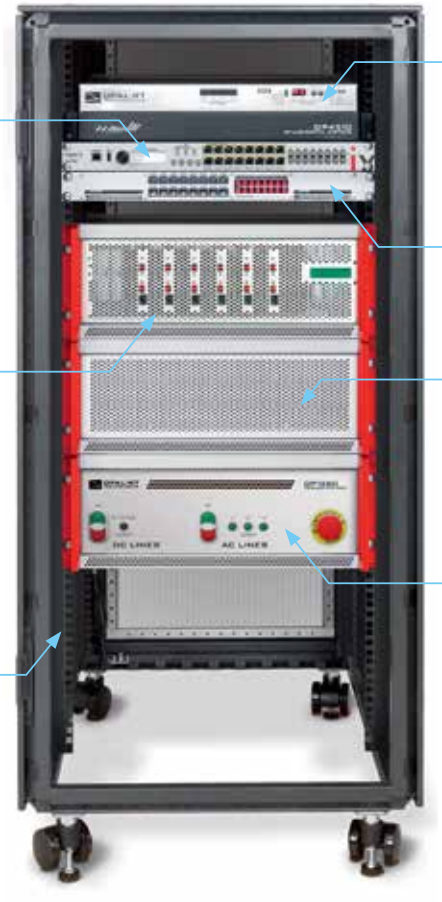
BOOMBOX RCP

- 16 analog inputs, 16 fiber optic outputs, 8+8 digital I/O, CAN
- Hardware protections
- 300 MHz TI DSP
- Up to 200 kHz sampling

POWER CONVERTER(S)

- Reconfigurable topology
- 6x PEB power modules max 800V / 32A or 400V / 46A
- Variable-speed cooling
- Up to 50 kHz switching

19" CABINET



OPAL-RT OP4510

- 4-core CPU, Xeon E3 3.5 GHz
- Kintex-7 XILINX FPGA, 325T
- 32/32 digital, 16/16 analog I/O
- Interface for BoomBox RCP

HIL INTERFACE

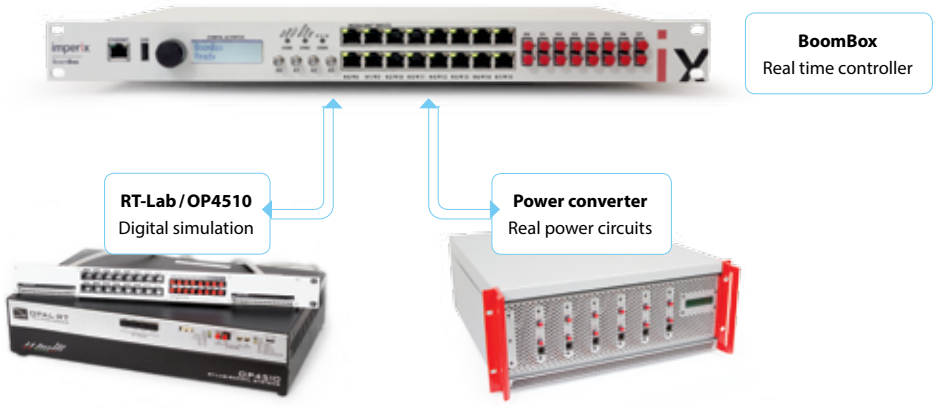
PASSIVE ELEMENTS

- 6x inductors (2.5mH, 20A)
- 2x LC-type common-mode EMC filters (3-phase)
- External voltage sensors
- External relays and breakers

AC / DC BREAKERS

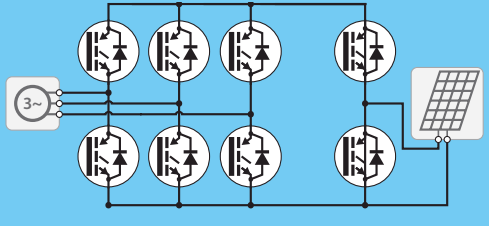
- Circuit disconnectors
- AC / DC breakers
- Controllable relays
- DC voltage sensor
- 3x AC voltage sensors

OUR MULTI-PURPOSE TEST BENCH SUPPORTS BOTH HIL SIMULATION AND LOW-VOLTAGE EXPERIMENTATION WITH EASY-TO-USE RECONFIGURABLE HARDWARE



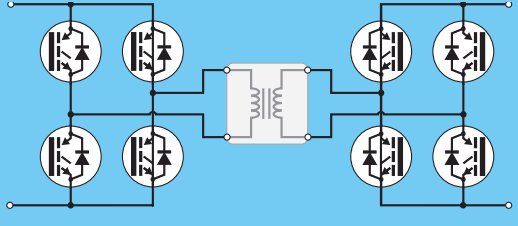
Users can use all six half-bridges to implement back-to-back converters, such as grid-tied var-speed drives, HVDC systems, etc. Alternately, fewer modules may be sufficient for applications such as PV inverters, battery chargers, etc.

Thanks to the complete flexibility in the connections of the modules, isolated DC/DC systems are also supported, such as DAB, resonant converters or similar topologies. Interleaved DC/DC systems are of course within reach as well.



PV INVERTER

Grid-tied central inverter for photovoltaic application



BATTERY CHARGER

Single-phase inverter with isolated DC/DC converter

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Drivelab kit

Test bench

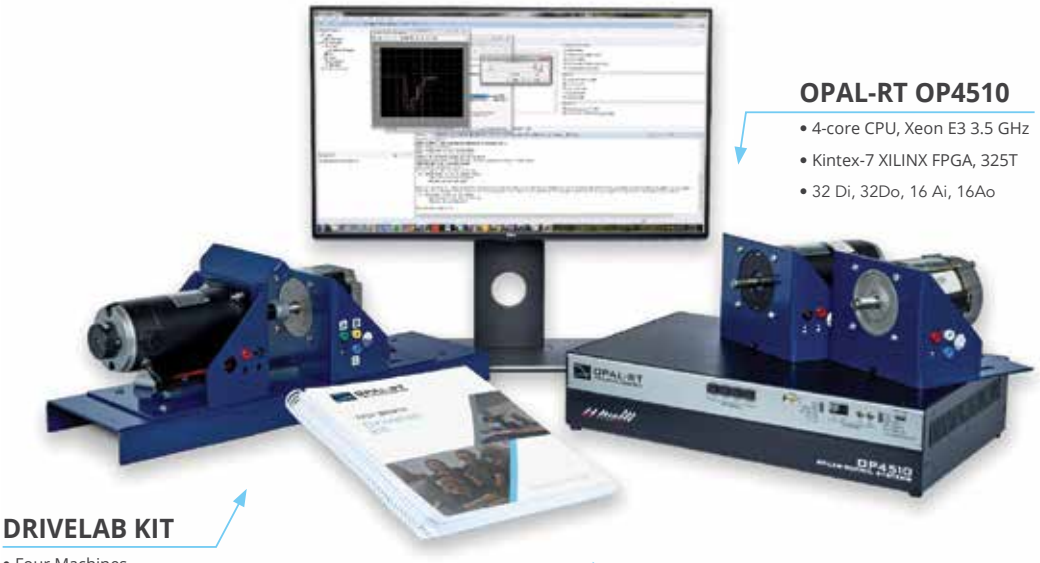
OP1640

"This kit enables mastery of electric drive concepts, from simulation of the whole virtual system to implementation on the real physical test bench."

Danielle Nasrallah, P.Eng, Ph.D
Technical Lead in Advanced Control and Electric Drives

The Drivelab Kit is a fully integrated motor drive laboratory, designed to enable students to perform a variety of experiments on AC and DC machines. As learning outcomes, students will have: hands-on experience with hardware including power electronics, motors, sensors and measurement instruments, and will learn parameter identification and motor modeling, current and speed control loop design, and scalar and vector control techniques.

TEST BENCH OFFER



OPAL-RT OP4510

- 4-core CPU, Xeon E3 3.5 GHz
- Kintex-7 XILINX FPGA, 325T
- 32 Di, 32Do, 16 Ai, 16Ao

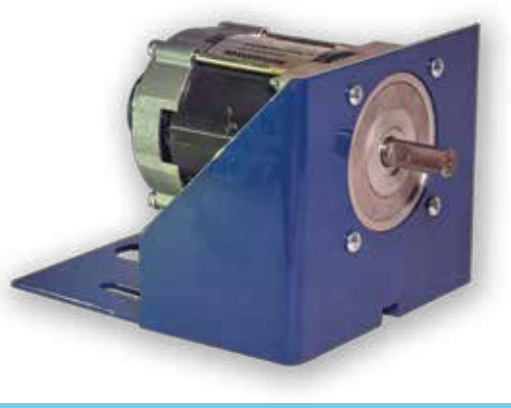
DRIVELAB KIT

- Four Machines
  1. brushed dC motor with quadratic encoder
  2. brushless dC motor with Hall Effect encoder
  3. Squirrel-cage induction motor with quadratic encoder
  4. brushed dC generator with variable resistor
- Power electronics inverters
- Voltage and current sensors
- Braking chopper

COURSEWARE

Power electronics HIL teaching laboratory Modules 1 to 4

OUR DRIVELAB KIT COMES WITH FOUR MODULES



MODULE 1:
Hands-On Setup

OBJECTIVES

- Become familiar with hardware and sensor calibration.

Laboratory Exercises include:

- Understand the mechanical setup: motors and coupling.
- Understand the electrical setup: drivelab mapping box, real-time simulator and cables.
- Calibrate sensors.

MODULE 2:
DC Motor Drives

OBJECTIVES

- Learn the principles of operation of a DC motor.
- Design a DC motor drive.

Laboratory Exercises include:

- Identify electrical and mechanical steady-state parameters.
- Simulate virtual motor.
- Design: (i) current control, (ii) speed control.
- Understand fourquandrant operations.

MODULE 3:
BLDC Motor Drives

OBJECTIVES

- Learn the principles of operation of a BLDC motor.
- Design a BLDC motor drive.

Laboratory Exercises include:

- Identify electrical and mechanical steady-state parameters.
- Simulate virtual motor.
- Design: (i) six-step control, (ii) vector control.

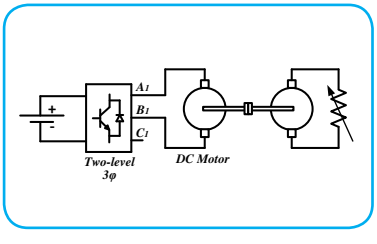
MODULE 4:
Induction Motor Drives

OBJECTIVES

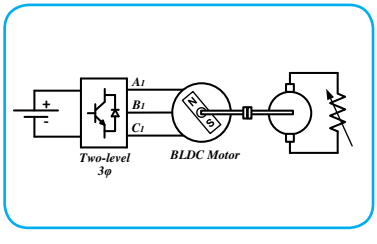
- Learn the principles of operation of an induction motor.
- Design an induction motor drive.

Laboratory Exercises include:

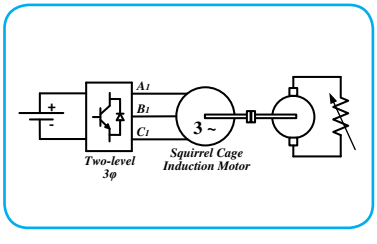
- Identify electrical and mechanical steady-state parameters.
- Simulate virtual motors.
- Design: (i) V/F control, (ii) vector control.



MODULE 2



MODULE 3



MODULE 4

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HIL and RCP Simulation Systems for Electric Motors

Test bench

OP1600 **OP1620**

"Take your wind energy system control design further into real-world implementation, and speed up the testing and tuning of your actual controller with OPAL-RT's RCP and HIL courseware".

Sergio Atayde M.Eng
Field Application Engineer
Control, Power electronics and WECS specialist

ELECTRIC MOTOR LABORATORY CURRICULUM GOALS

The OPAL-RT system, combined with Festo hardware, enables educators to fully teach the V-cycle principles used in the industry. Students and researchers can build a model and then validate the same model against a real system.

This laboratory combines the best of both OPAL-RT and Festo solutions to deliver academic researchers and teachers the ideal Hardware-in-the-Loop (HIL) and Rapid Control Prototyping (RCP) simulation system to conduct experiments and teach in the fields of electrical machinery, power converters and wind energy generation.

TEST BENCH OFFER

OPAL-RT OP4510

- 4-core CPU, Xeon E3 3.5 GHz
- Kintex-7 XILInX FPGA, 325T
- 32 Di, 32Do, 16 Ai, 16Ao

OPAL-RT OP8660

HIL Controller Interface

- 16 High Current- max 15A
- 16 High Voltage Probes- max 600V

(8540) (8505) (8331, 8311, 8374, 8857)

FESTO OP1620

- Four Quadrant Dynamometer 2KW- (8540)
- Induction Motor DFIG- PMSM (8505)
- IGBT Chopper/ Inverter (8857)
- Line Inductors, Resistive Load and Capacitive Load (8331, 8311, 8374)

OUR HIL AND RCP SIMULATION SYSTEM FOR ELECTRIC MACHINES COMES IN TWO FORMATS WITH THREE MODULES EACH

FESTO

OP1600

The **200 W Festo** Electromechanical Training System contains:

- Dynamometer (8960)
- Power supply (8821)
- PMSM (8245)
- DFIG, SYNC M/G, PMDC or SCIM (8231, 8241, 8213,8221)
- 2x 6-pulse IGBT (8837)
- Capacitive Load, Resistive Load or Line Inductors (8331, 8311, 8326-A)

OP1620

The **2-kW Festo** "Renewable Energy" System contains:

- Dynamometer (8540)
- Power supply (8525)
- PMSM (8505)
- Sync M/G, DC or SCIM (8507, 8501, 8503)*
- 2x 6-pulse IGBT (8857)
- Capacitive Load, Resistive Load or Line Inductors (8331, 8311, 8374)

* Optional

OBJECTIVES

- Cover the fundamental concepts of RPC
- Perform hands on exercises using Festo's power electronics and motor drive didactic hardware.

MODULE 1:

OP1600- OP1620
Fundamentals of RCP and operation

Laboratory Exercises include:

- Signal conditioning for RCP
- Interface with machines
- Interface with power electronics
- Control of driving dynamometers

MODULE 2:

OP1600- OP1620
Entry level application of RCP

Laboratory Exercises include:

- PID based speed control of machines
- Operation of 2-level inverter
- Regulation of a DC bus

MODULE 3:

OP1600
Advanced application of RCP

Laboratory Exercises include:

- Speed control of various machines: DC, IM, PMSM, WRIM.

OP1620
Advanced application of RCP

Laboratory Exercises include:

- Active filtering
- Advanced FOC control of a DFIG

Academic Special Offers

REAL-TIME SIMULATION IS MORE ACCESSIBLE THAN EVER.

OPAL-RT's ambitious challenge is to fully democratize simulation, making it affordable and accessible to every engineer and researcher.

Real-time simulators such as the ones manufactured by OPAL-RT are widely used and recognized in the industry as a standard method of validation of engineering concepts. Experiments performed with real-time simulators are also increasingly considered high-quality scientific work and are commonly published in conferences and publications of well-known organizations such as IEEE or CIGRE.

Our academic discount puts all of this within your reach, and helps stop budgetary concerns from being a limitation. We'd like to be your ideal research laboratory partner.

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Test and Teach With Us

450 UNIVERSITIES AND COUNTING...

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 manufacturers, 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 minimizing initial investment and their cost of ownership. OPAL-RT also develops mathematical solvers and models specialized for accurate simulation of power electronic systems and electrical grids. 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 IS THE LEADING DEVELOPER OF OPEN REAL-TIME DIGITAL SIMULATORS AND HARDWARE-IN-THE-LOOP TESTING EQUIPMENT.

Please contact your representative/ reseller for details.

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