OPAL-RT TECHNOLOGIES

ACADEMIC OFFER

FOR UNIVERSITIES & COLLEGES

WWW.OPAL-RT.COM

Table of Contents

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 workflows

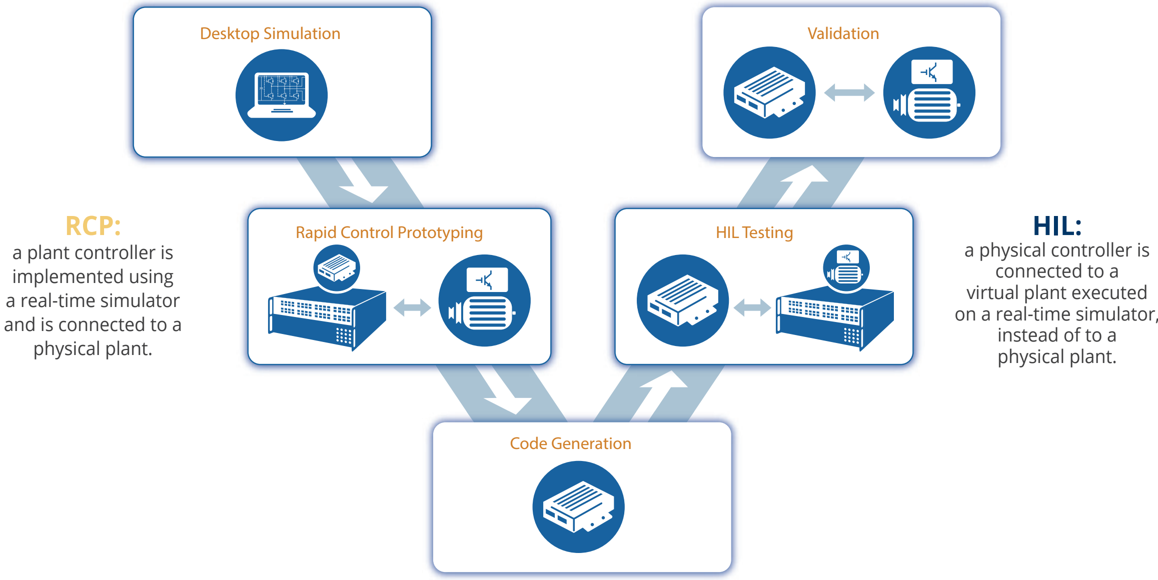
INTERACTIVITY AND VERSATILITY

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

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.



Our Bundles

RAPID CONTROL PROTOTYPING

RCP

BDL45-100

RT-LAB

HARDWARE IN THE LOOP

HIL

Power Electronics

BDL45-411

HYPERSIM

BDL45-300

RT-LAB

+

eHS | FPGA-based Power Electronics Toolbox

RT-LAB

+

ARTEMiS | CPU-based Electrical Toolbox

BDL45-410

Our Simulator

OP4510

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 electronic simulation.

The OP4510's compact 2U chassis works equally well for desktop or rack-mounted setups, while providing up to 128 high-performance analog/digital channels with signal conditioning and four SFP-GTX optical high-speed links for hardware interfacing. The standard configuration includes 32 digital outputs, 32 digital inputs, 16 analog outputs, and 16 analog inputs.

HARDWARE

- 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)

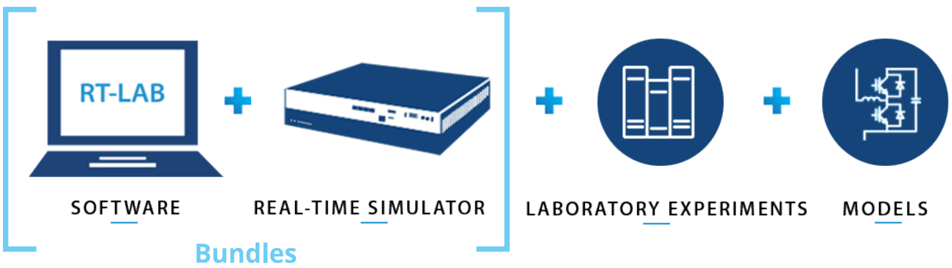
Teaching Laboratory Kits

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

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

TWO TYPES OF TEACHING LABORATORY KITS

Courseware Kits



Test Benches

Teaching Laboratory Kits

COURSEWARE KITS

PRODUCTS

KIT NUMBER	SUBJECTS
OP1130	Power Electronics
OP1140	Power Systems (PS)
OP1160	Electric Machines

TEST BENCHES

PRODUCTS

TB NUMBER	SUBJECTS
OP1310 OP1320	Power Electronics
OP1600 OP1620	Simulation Systems for Electric Motors

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

DEFINITION

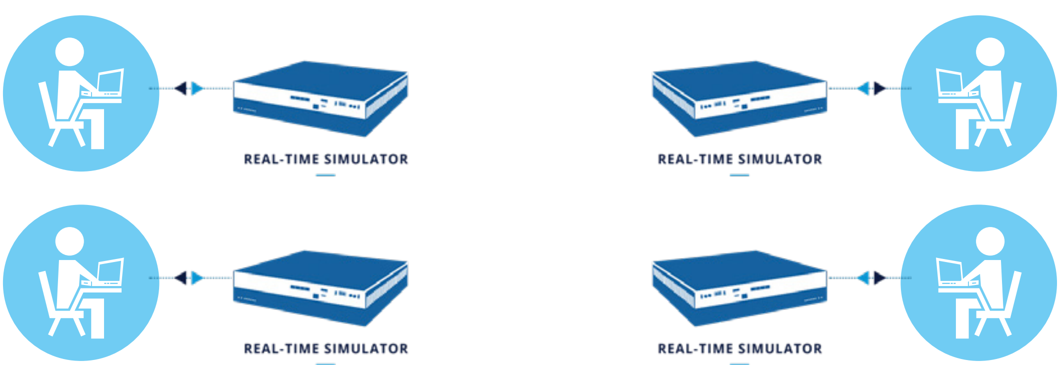
Run-Time: Allows the running of any courseware or any model developed with the development version

Development: Allows the development, compilation and running of models

IN THE CLASSROOM

Development Simulator for the teacher

Run-Time for the students



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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

The 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, resulting 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

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

MODULE 2:

AC-DC Rectifiers

OBJECTIVES

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

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

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: (Module 1)

- Impact of varying parameters of converter
- Effect of varying the duty cycle

Laboratory Exercises include: (Module 2)

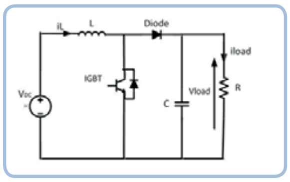
- Impact of varying rectifier parameters
- Calculation of the form factor and the ripple factor
- Impact of activation of smoothing capacitor

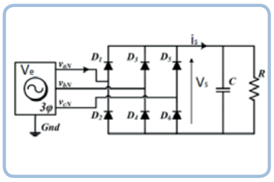
Laboratory Exercises include: (Module 3)

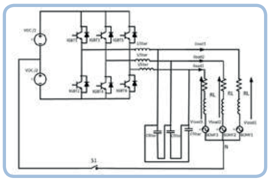
- Impact of neutral connection and filtering
- Impact of varying PWM frequency and dead time

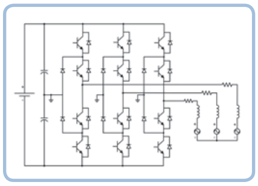
Laboratory Exercises include: (Module 4)

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









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 real time 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

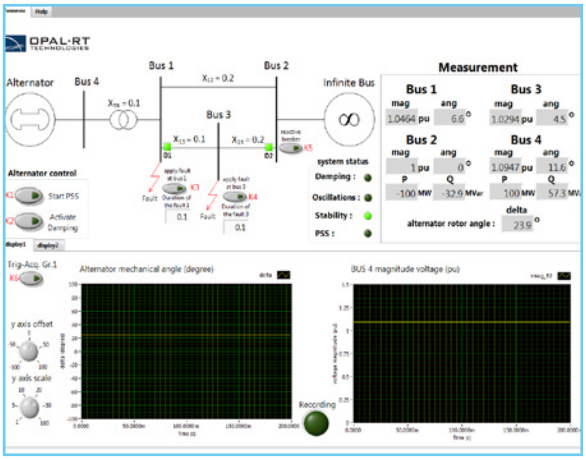
COURSEWARE

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:
Phasor-domain mode

MODULE 2:
Time-domain mode

MODULE 3:
Modes comparison

IN EACH MODULE, YOU PERFORM:

PART 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.

PART 2:
Damper Windings
Laboratory Exercises include:

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

PART 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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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

Starter Kits

OP1310 **OP1320**

"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)

These kits are ideal when a maximum flexibility on the topology is needed. Indeed, converters can be easily assembled (and de-assembled!) by simply swapping modules in and out of an open chassis. This allows for a high reusability of the modules. As a side benefit, such an approach also emphasizes the modular nature of numerous converter topologies.

POWER ELECTRONICS STARTER KITS OFFER

OP1310 STARTER KIT

HARDWARE + SOFTWARE

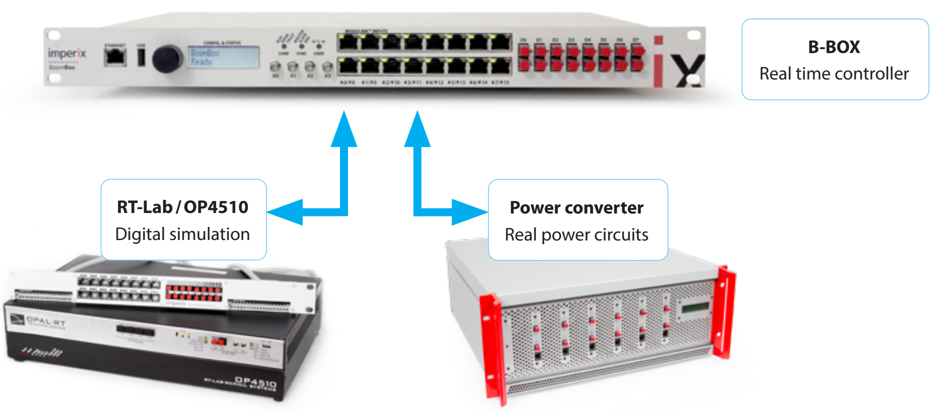
- B-BOX + Software Lite
- Open chassis with 3 x PEB 4046
- 4 x voltage sensors
- All needed cables

OP1320 HIL KIT

HARDWARE + SOFTWARE

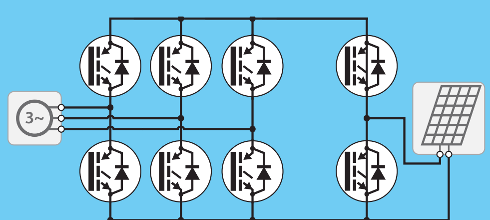
- OP4510 + RT-LAB + eHS32
- B-BOX + Software Suite
- SimulinkTM blockset
- Open chassis with 3 x PEB 4046
- 4 x voltage sensors
- All needed cables

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



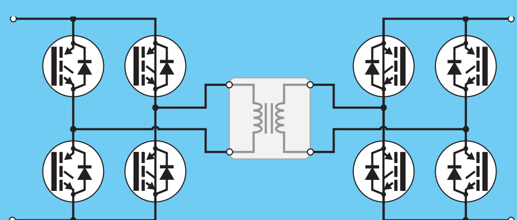
Users can use all six half-bridges to implement back-to-back converters, such as grid-tied var-speed drives, HVDC systems, etc. Alternately, fewer modules may be sufficient for applications such as PV inverters, battery chargers, etc.

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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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

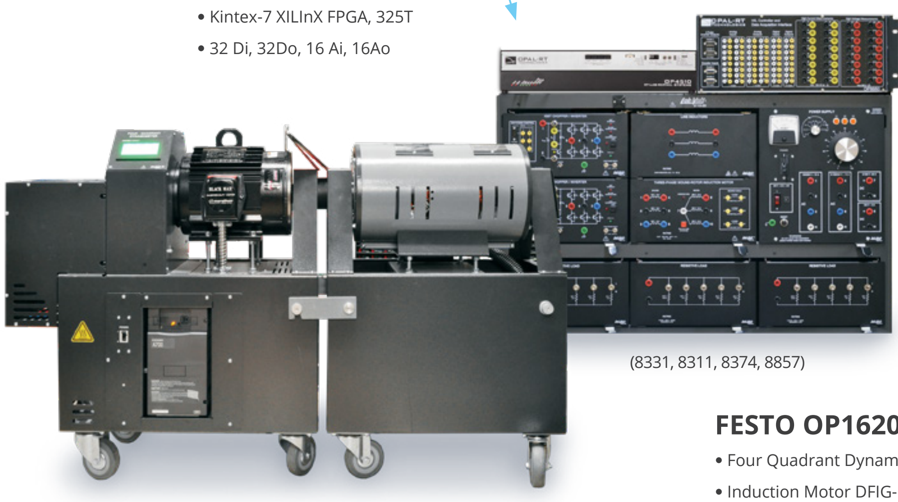
OPAL-RT OP8660

HIL Controller Interface

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

OPAL-RT OP4510

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



(8331, 8311, 8374, 8857)

(8540) (8505)

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

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 RCP
- 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:

- Active filtering
- Advanced FOC control of a DFIG

MODULE 3:

OP1620
Advanced application of RCP

Laboratory Exercises include:

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

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.

DISCOUNT

Please contact your representative/reseller for details and academic discount.

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