Rapid Control Prototyping Solutions
Electrical Drive, Power Conversion and Power Systems

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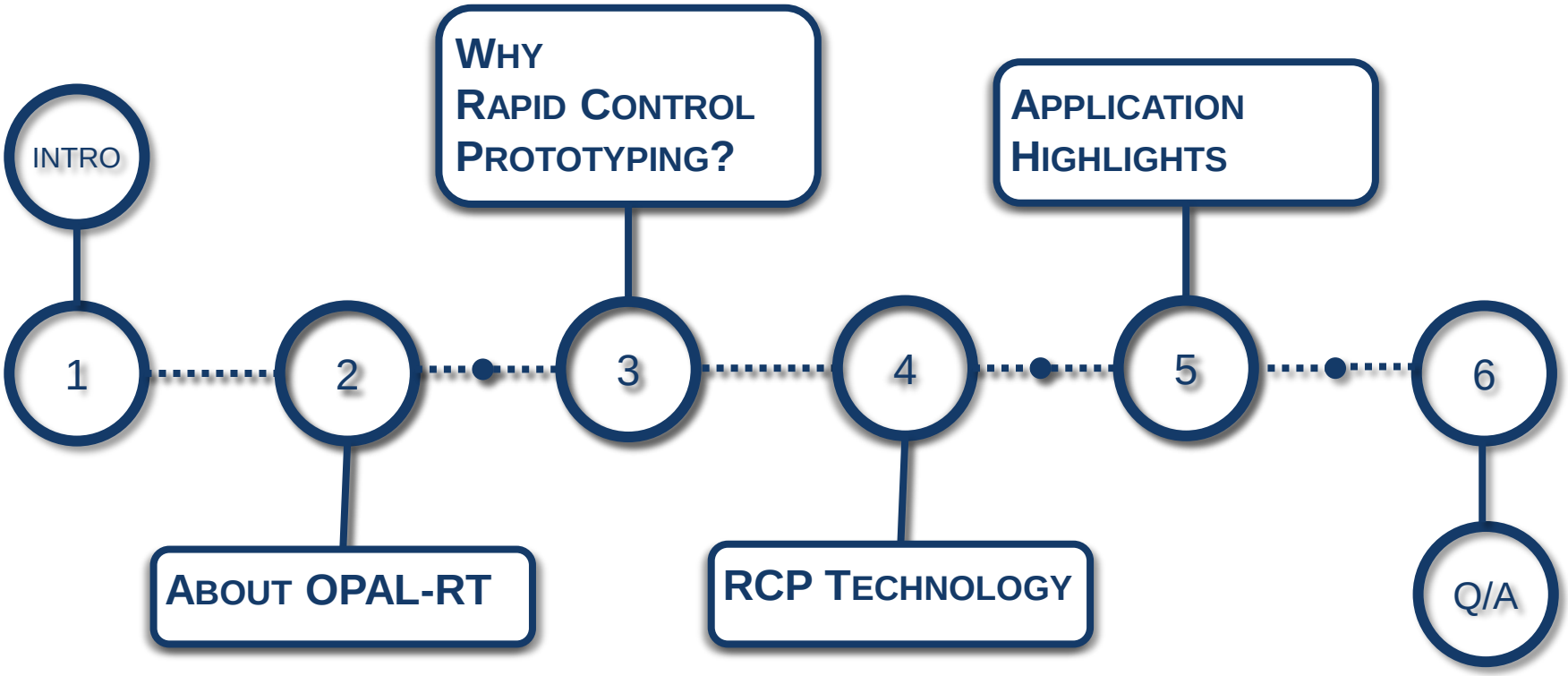
Presentation outline



Key Take-Aways

- Find errors at the start of your project to save time, costs and increase overall quality.
- Easily build real-time execution of control design; tweak and tune it with efficient tools.
- Efficiently address power electronics, electric drive and power systems with OPAL-RT RCP solution.

OPAL-RT TECHNOLOGIES in Brief

- Established in 1997
- Strong R&D with 20% of turnover reinvested
- Large and diversified customer base
- One-stop-shop for Model-Based Engineering Simulators

- **Power Electronics**
- **Power Systems**
- Automotive
- Aerospace

- **Rapid Control Prototyping (RCP)**
- Hardware in the Loop (HIL)
- MATLAB/Simulink Integration

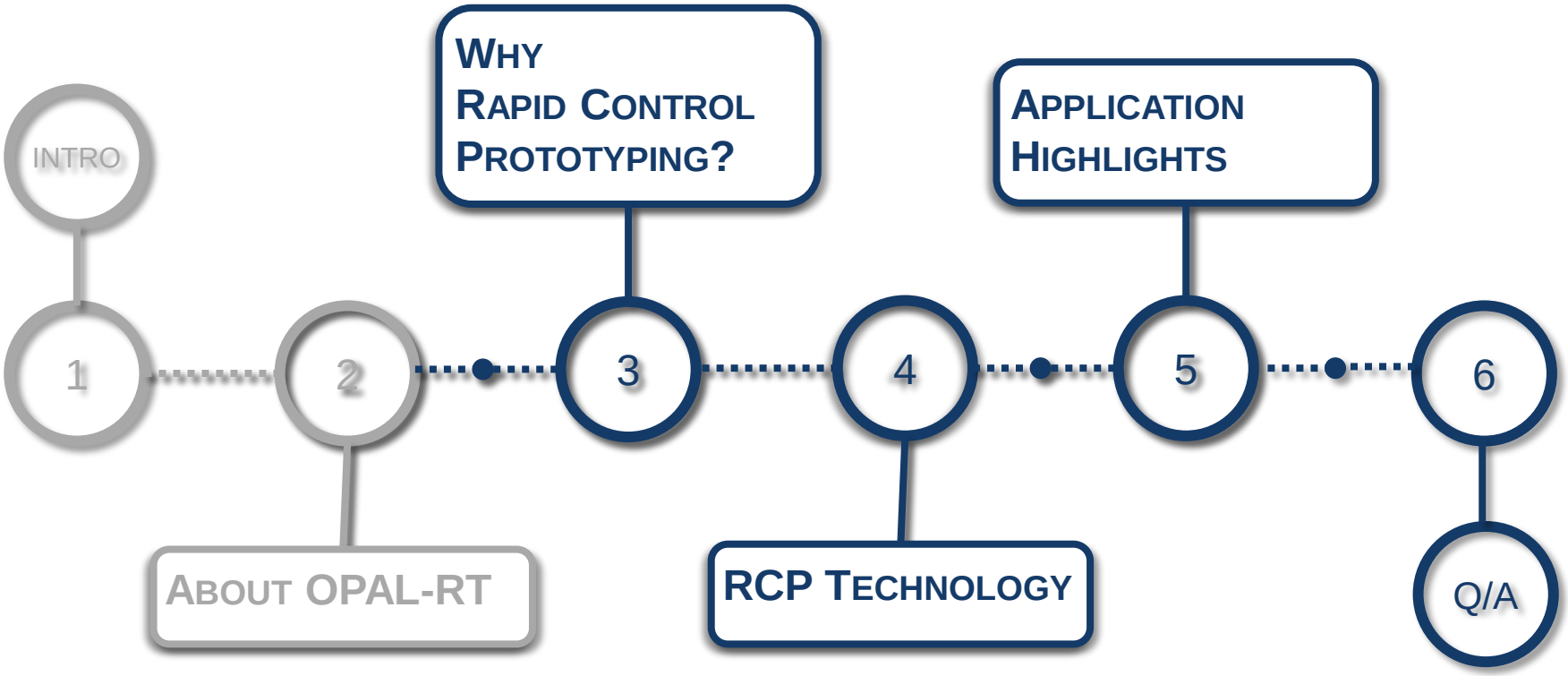
Client List (partial)

Automotive

Aerospace & Defense

Education & Research


Electrical & Power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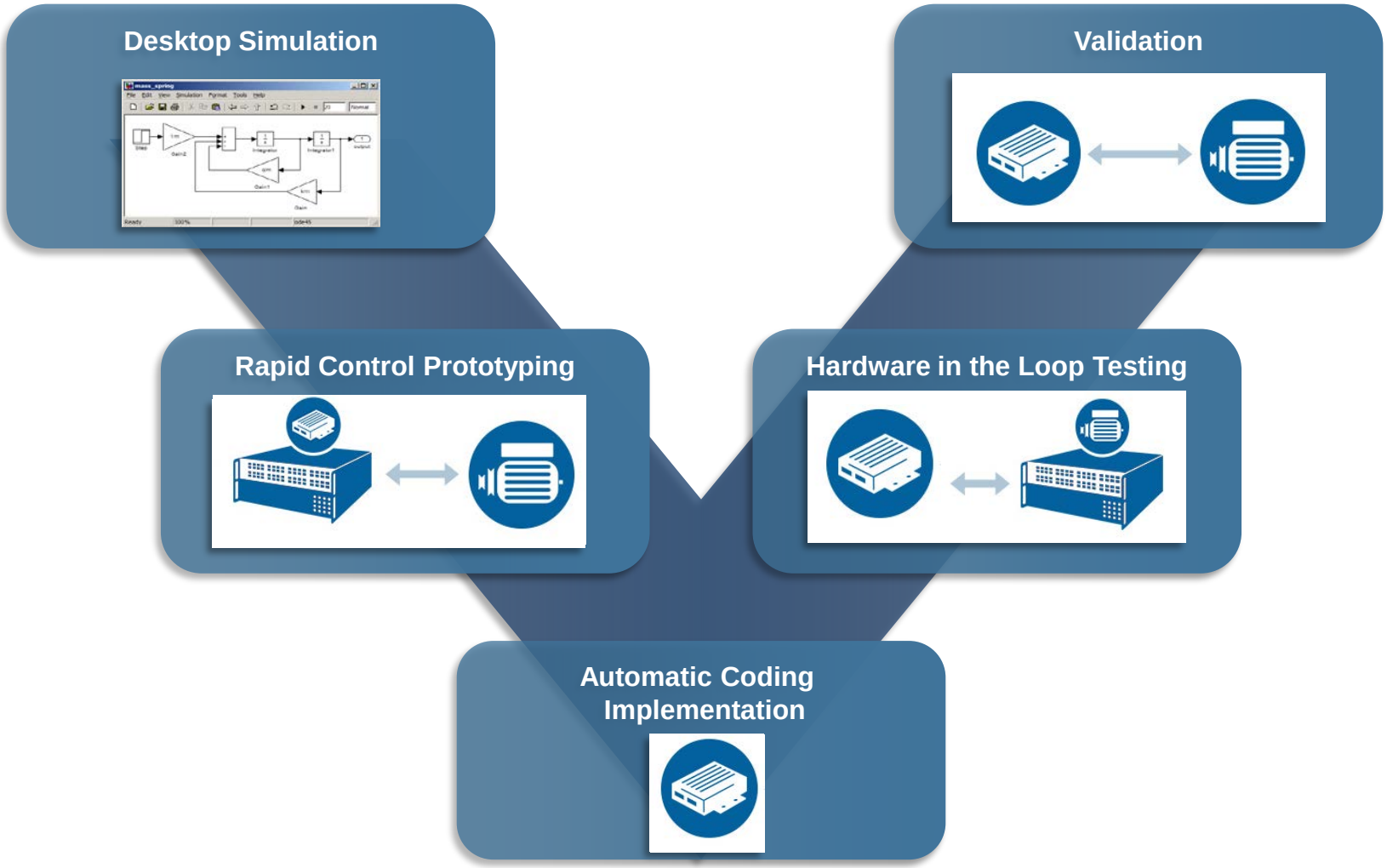
Model-Based Engineering

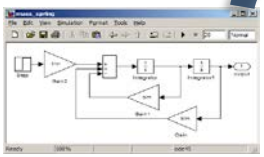


What is Rapid Control Prototyping ?

Workstation

Real-Time Computer

Plant



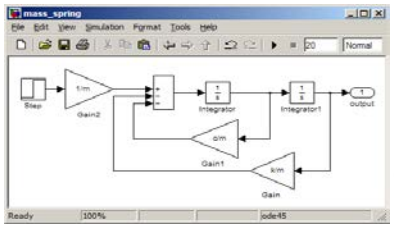
Electronic Control Unit

Model Design
Signal Acquisition & Display
Parameter change

Real-time model execution on CPU
Fast I.O and signal processing
Communication
Real-time data logging

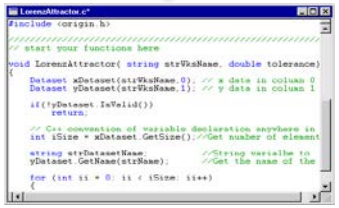
Assess control designs in a representative environment.

Rapid design iteration



Model Design
I/O configuration

Automatic Code Generation

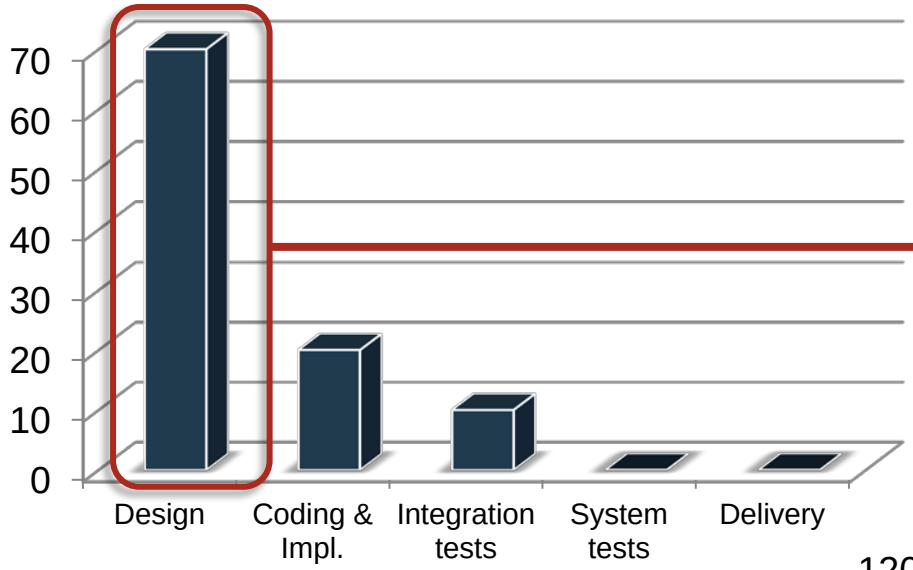


Test
(easy parameter change and data visualization)

Real-Time Execution

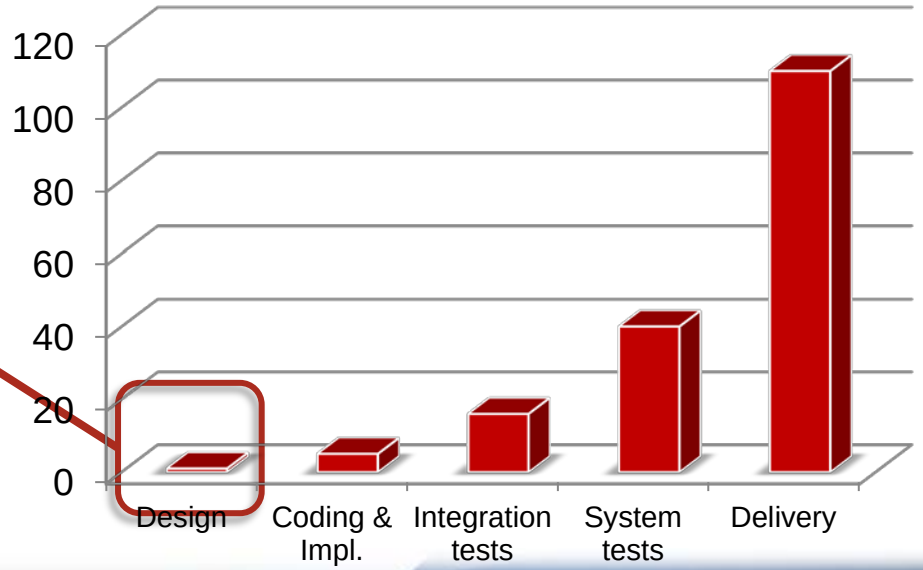
Benefits of RCP

When software errors are **introduced**



Verify controler design at the **earliest stage…**

Cost of fixing software errors

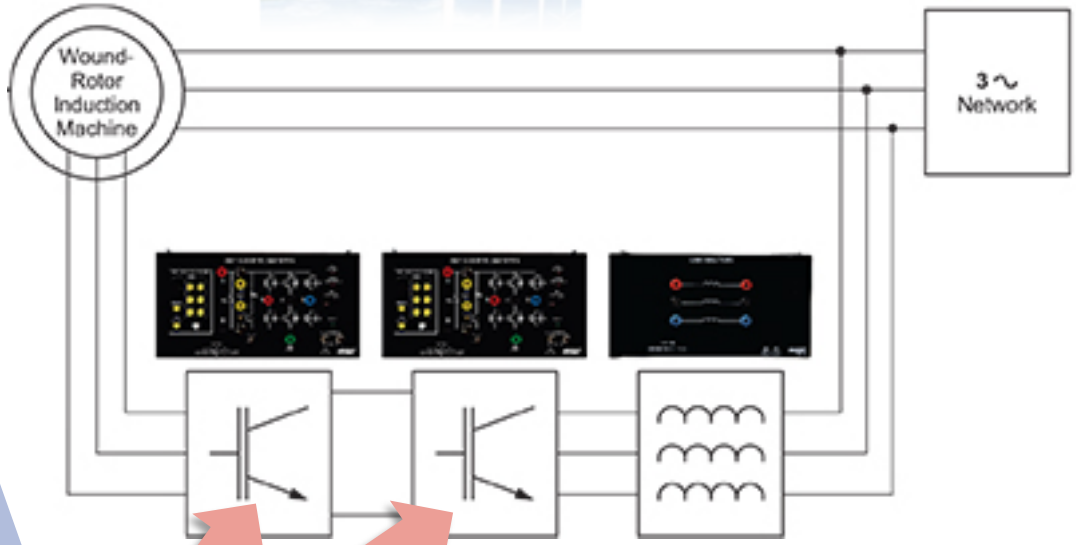


… at **low rework** and **validation cost**

LIVE Demonstration - Overview

- Prepare a model for real-time execution
- Connect to a real plant, run experiments
- Benefit from handy software interfaces and dynamic parameter access to easily tweak and tune control design

LIVE - DFIG Control Demonstration



OPAL-RT TECHNOLOGIES

LIVE Demonstration Outcome

Check DFIG control design in a representive environment

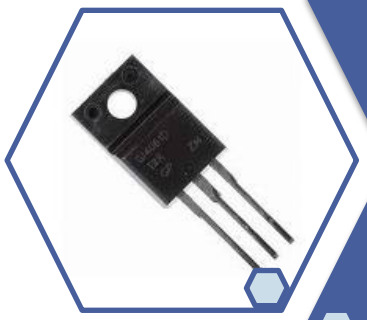
Run your model in real-time without coding

Interact in real-time with control model

Tune and fix, iterate rapidly

Reuse for several projects

What makes OPAL-RT Unique



SmartGrid

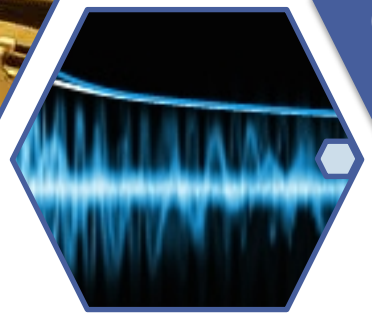
Fast controls

Complex topologies

Powerful computing

FPGA firmware

intel inside Xeon



True RT datalogging

OPAL-RT Dedicated Solutions

RCP-DRIVE

Electric Drives

- Hybrid Electric Drive
- Electric Steering
- Electrical actuators

High Power Industrial drives

- Multi-machine drives
- Multi-phase drives
- Marine, Oil & Gas
- Off-track vehicles
- Trains

Teaching Laboratory

- Electric Drive 250W kit
- Doubly Fed Induction Generators 2KW kit

RCP-GRID

Renewable Energy

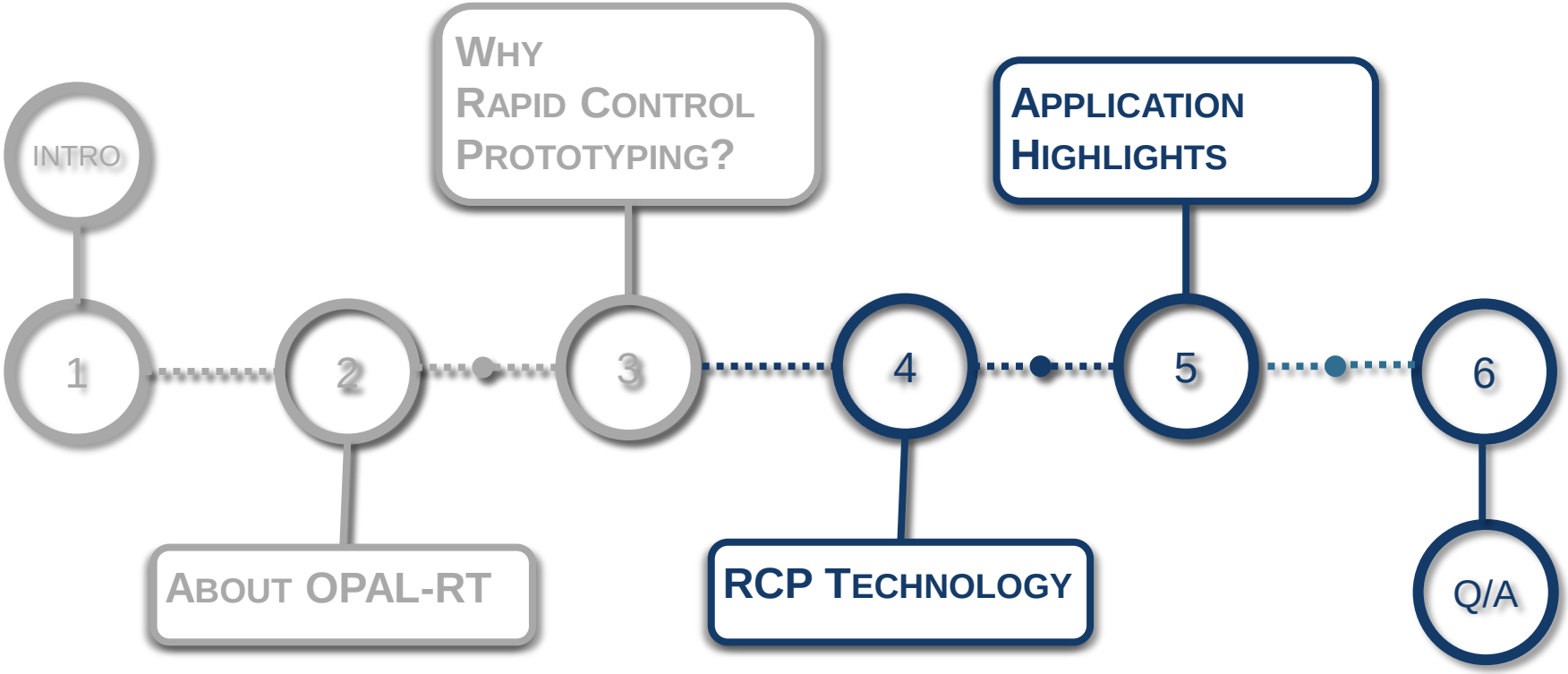
- Renewable Energy Resources
- Storage
- Smart Home Automation

Power Systems & Smart Grids

- Protection Relay
- PMU
- SCADA
- Energy Management Systems

High Voltage Power Electronics

- HVDC
- Meshed DC grids
- MMC
- FACTS
- SVCs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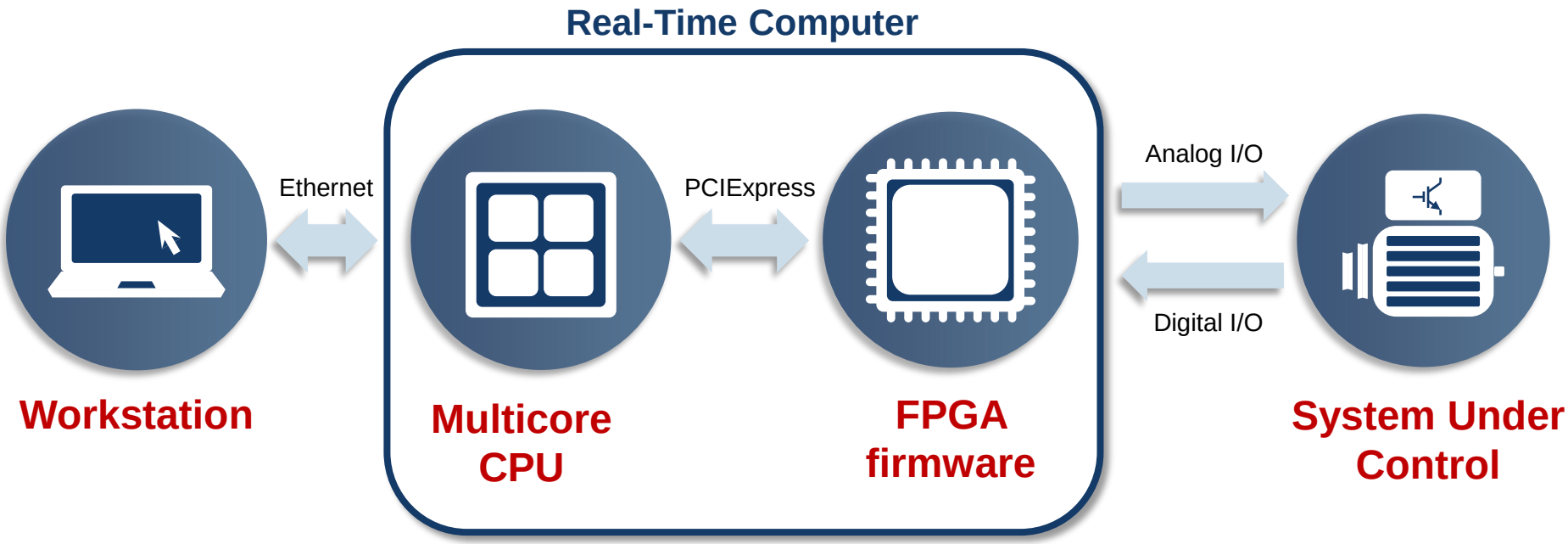
Fast and versatile architecture



Communication Options

CAN, RS232, RS485, LIN, ARINC, MILSTD 1553
Ethernet, IEC 61850, DNP 3.0, C37.118, …

Choice of form factor

OP 4500
(Q2 2013)

CPU : QuadCore & Sixcore XEON
FPGA : Virtex 6
IO : 96 channels max
Com. Boards : 4 max
Size :12'' x 15'', 2U size

OP 5600

CPU : QuadCore & SixCore XEON
FPGA Spartan 3, Virtex 6
IO : 256 channels max
Com. Boards : 6 max
Size : 14'' x 19'', 4U size

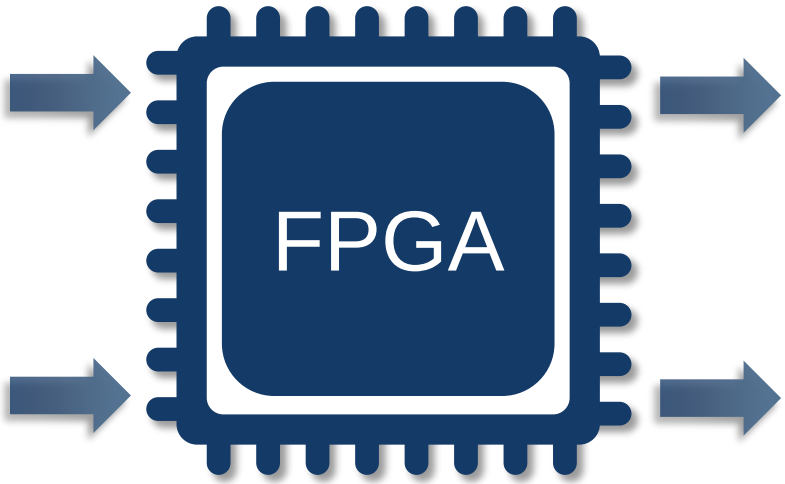
+

Signal converters & conditioning modules, electrical & optical

Flexible I/O Connectivity

Analog
ADC
Resolver Sinus/Cosinus Input
Resolver excitation input
Voltage Sensor
Current Sensor
Temperature Sensor

Digital
Quadrature encoder (A,B,Z)
Hall Effect
Synchronous Serial interface (SSI)
Serial Peripheral interface (SPI)
Custom protocol



Analog
DAC
Resolver excitation output

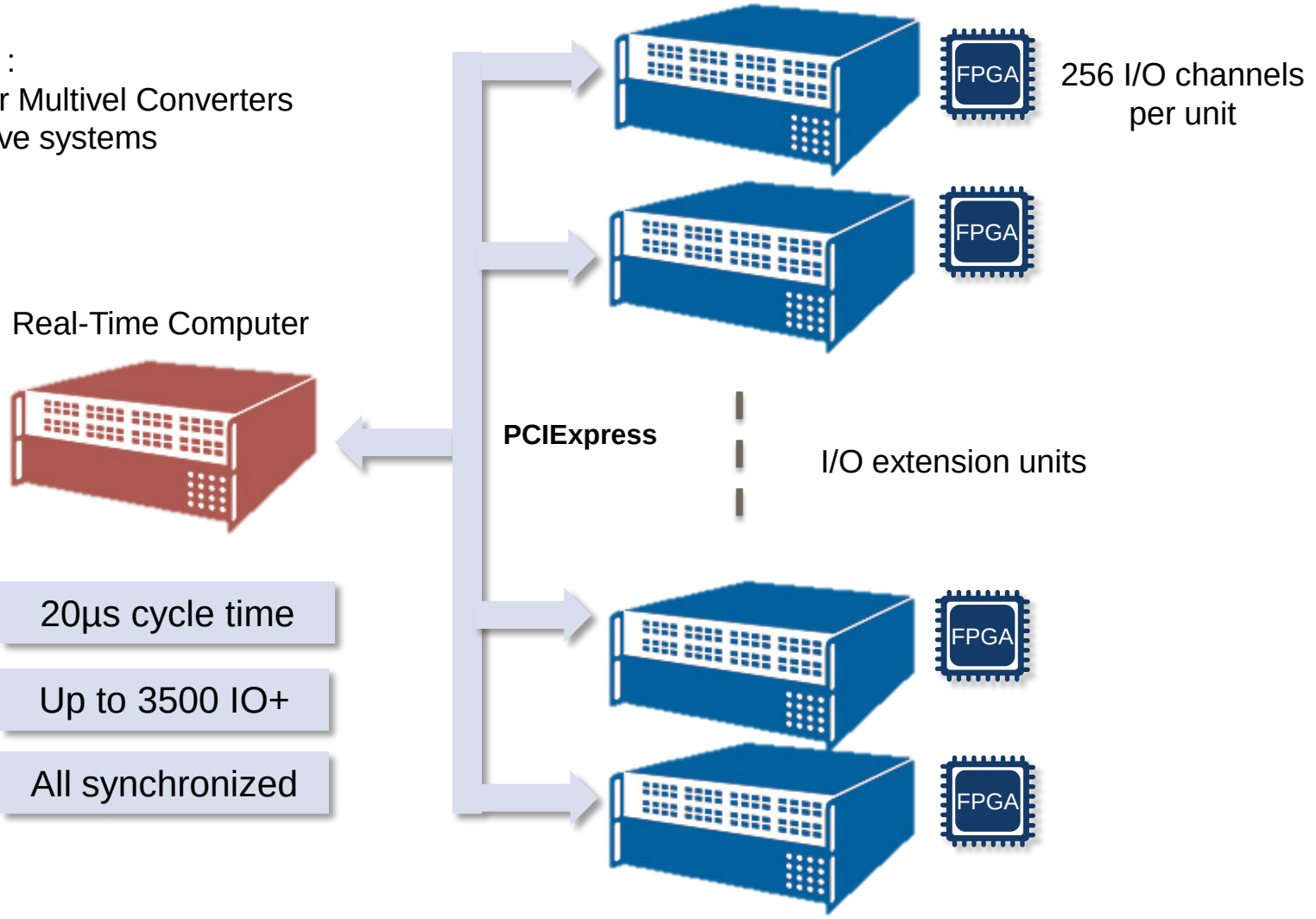
Digital
Gate Firing Out (PWM, SVM, …)
Synchronous Serial interface (SSI)
Serial Peripheral Interface (SPI)

FPGA Firmware
Input/Ouput management
Generic control functions, such as electric motor drive
Specific / user-made signal processing or control logics

Scalable I/O Solution

Optimal for :

- ✓ Modular Multivel Converters
- ✓ Multidrive systems



RCP-DRIVE FPGA Firmware

- **Easy to use** (Simulink blockset interface)
- **Flexible** PWM settings
- **Accurate**
- **Extrem performance**
  - Up to 120 KHz switching frequency
  - Multidrive configuration

Features :

- ADC – PWM synchonization
- Sensors setting
- Carrier wave mode
- Multi-carrier PWM (phase-shift method)
- Dead-time setting (10ns resolution)
- Interleaving (for multilevel topologies)
- Safety output in case of fault

Prototype Your Own FPGA Functions

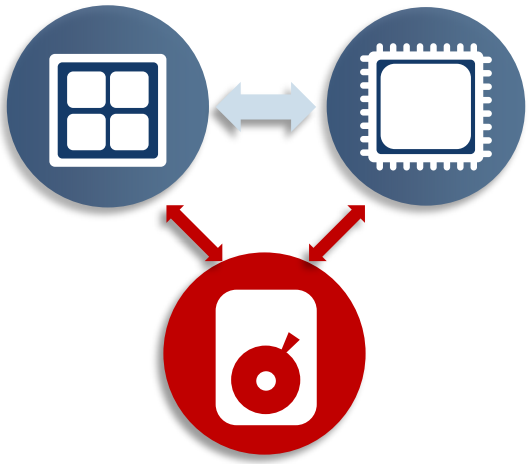
- Compatible with **Xilinx System Generator**
- Develop faster with **ready-made functions**
- **Access to I/O**, exchange data with **CPU**
- Supports **floating point** (Virtex 6 version)
- **RT Datalogging** of FPGA signals

OPAL-RT RT-XSG blockset :

- CPU data exchange
- IO Hardware access
- Frequency Measurement
- Mean-Square & Average
- Quadrature Decoder
- Resolver In
- …

Accurate Datalogging for Simpler Debugging

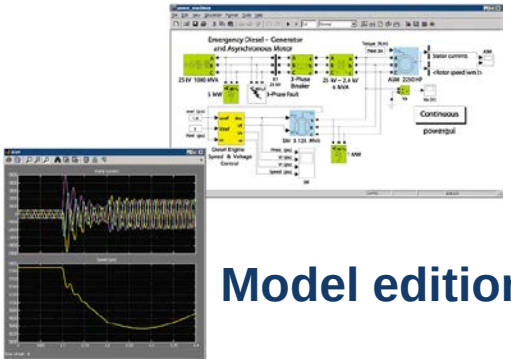
- A **must-have** for **fast controls** found in **power electronics** and **protection** applications
- **Real-time logging** of CPU/FPGA/IO signals
- Down to **10ns resolution**
- Stored in MATLAB format



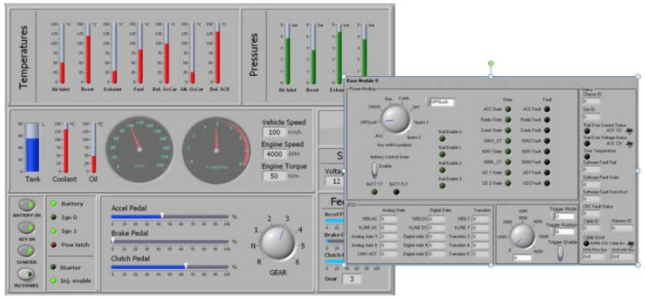
Internal Hard Drive

Advanced features :
- High frequency sampling
- External, internal or manual triggered

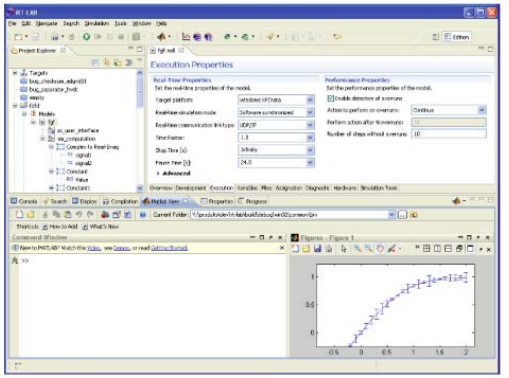
User-friendly Software Interface



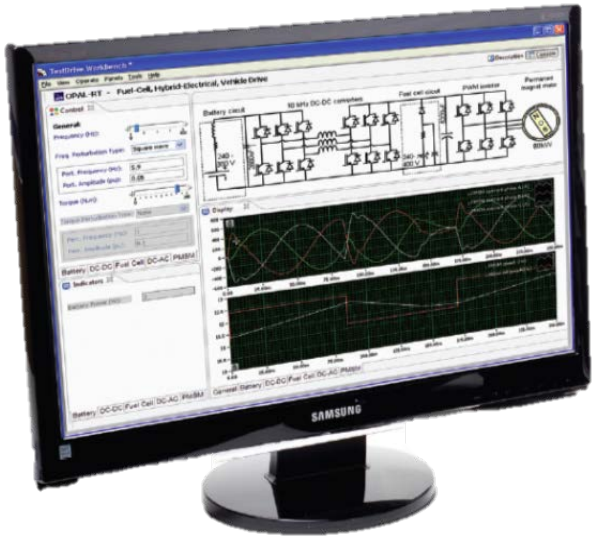
Model edition

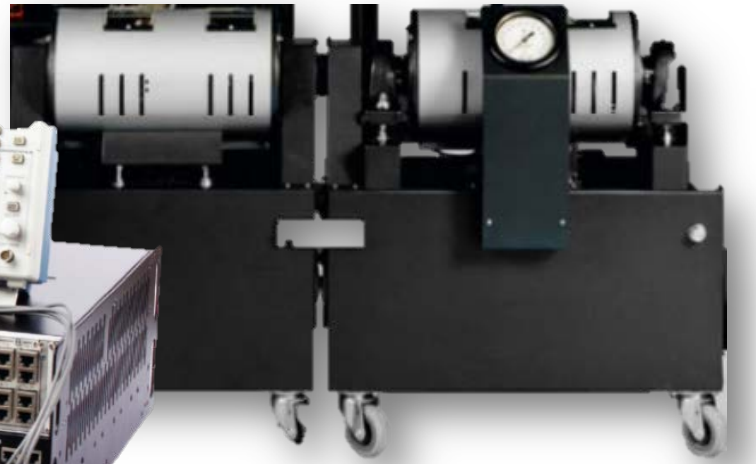


HMI



Project & Simulator Manager



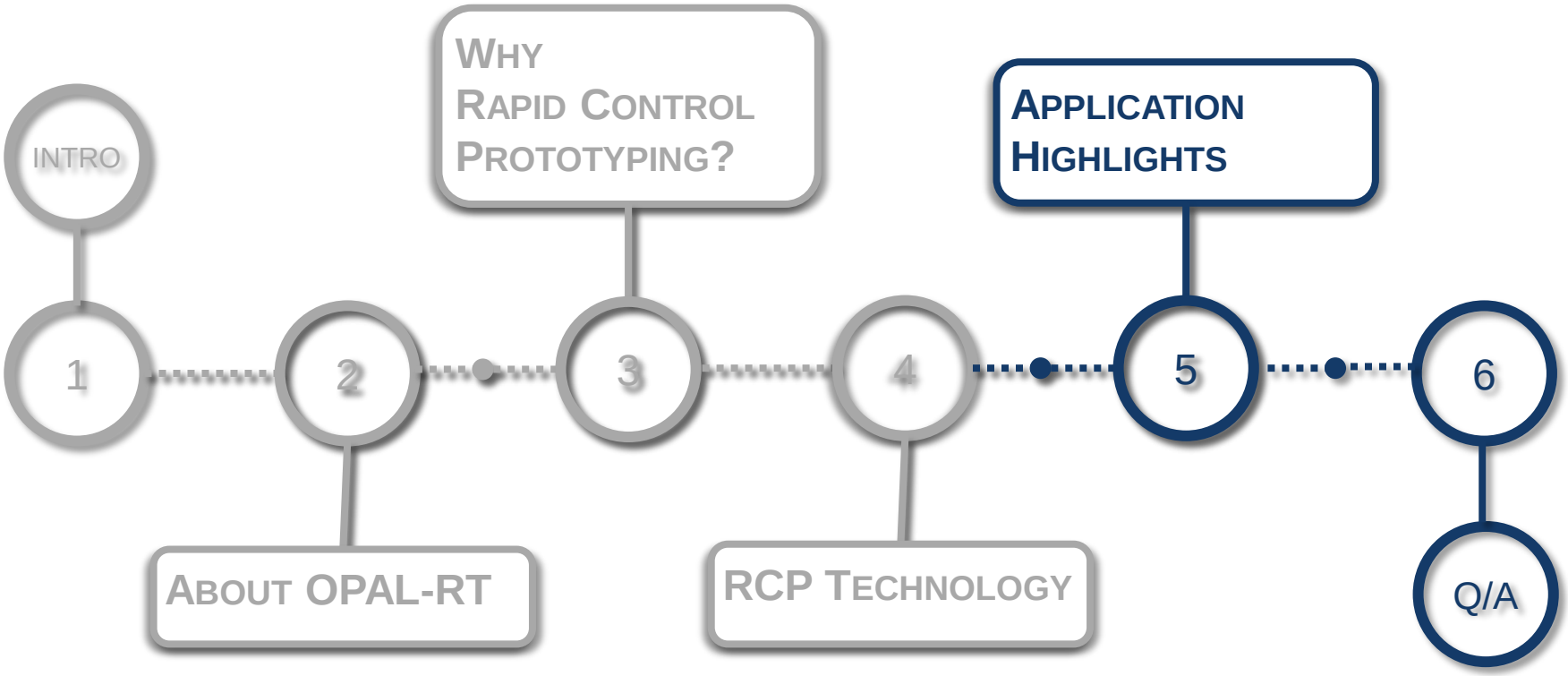


Dedicated Technologies for Power Electronics, Drive & Power Systems

a) **High performance levels : meet the most challenging needs**
   - Lowest cycle time on the market, fastest CPU & FPGA
   - Very large I/O configuration (MMC, …)

b) **RCP FPGA Firmware : fast, flexible and easy to use**
   - Generic I/O and control firmware
   - Custom FPGA controls

c) **Real-Time Data Logging : efficient troubleshooting**
   - High speed & lossless
   - I/O, CPU & FPGA signals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Application Highlights: Electric Motor Drive

Electric Drives

- Hybrid Electric Drive
- Electric Steering
- Electrical actuators

Valeo

Electric Motor Drive Control
(PMSM, BLDC, Induction…)

- Range extender R&D development (electric vehicle program)
- Used for engineering of new products (control algorithm validation)
- Saves expensive prototype ECU development, allows rapid control validation

Illustration picture

Application Highlights: Modular Multilevel Converters

High Voltage Power Electronics

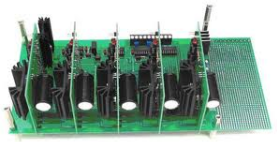
- HVDC
- Meshed DC grids
- MMC
- FACTS
- SVCs

Chosen by :

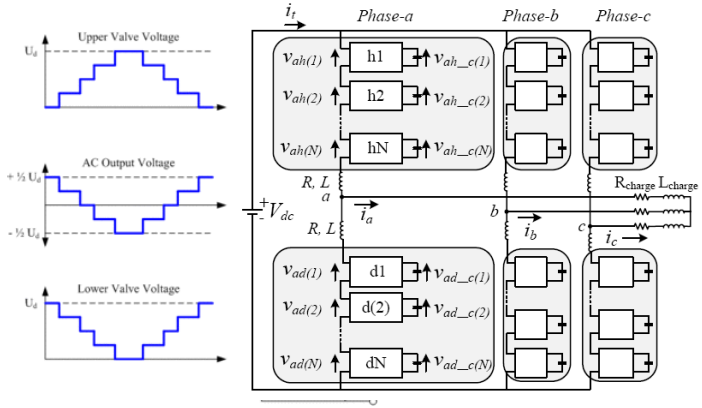
The University of Nottingham

Imperial College London

Aston University Birmingham



Cell & Pole Controls



- Cycle time of 20µs
- 2500 IO channels, all synchronized
- Supports Half-Bridge and Full-Bridge Mode
- Optical interface (option)

OPAL-RT TECHNOLOGIES

Application Highlights: PMU and Relay Prototyping

Power Systems & Smart Grids

- Protection Relay
- PMU
- SCADA
- Energy Management Systems

GPS clock

Real Power System

Real-Time EMT Simulation of Power System

- IEC 61850, IEC 60870-5-104, DNP 3
- MODBUS, Ethernet, OPC

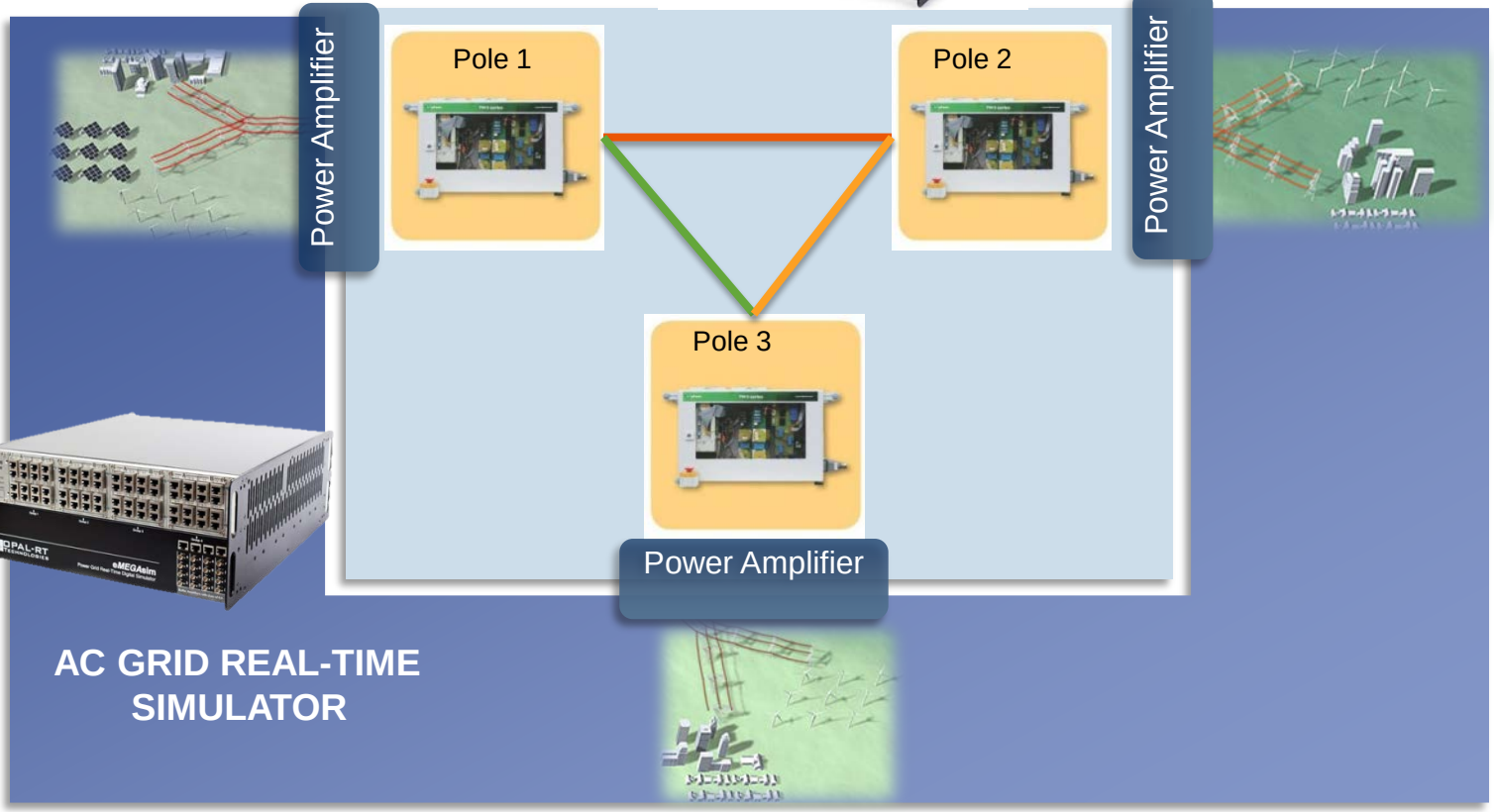
OPAL-RT TECHNOLOGIES

Application Highlights: MTDC Grids

High Voltage Power Electronics

- HVDC
- Meshed DC grids
- MMC
- FACTS
- SVCs

Pole Controls



Application Highlights: Education Laboratory – 2KW DFIG

Teaching Laboratory

- Electric Drive 250W kit
- Doubly Fed Induction Generators 2KW kit

DFIG Control
Wind profile simulation

Thank You

Questions?

Sources

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