On Board Power Electronics Real-time Simulation, Verification and Validation

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OPAL-RT TECHNOLOGIES

- Established in 1997, HQ in Montreal, CA
- Offices, subsidiaries and distributors worldwide
- Over 160 Employees
- More than 600 customers
- More than 20% of turnover reinvested in R&D

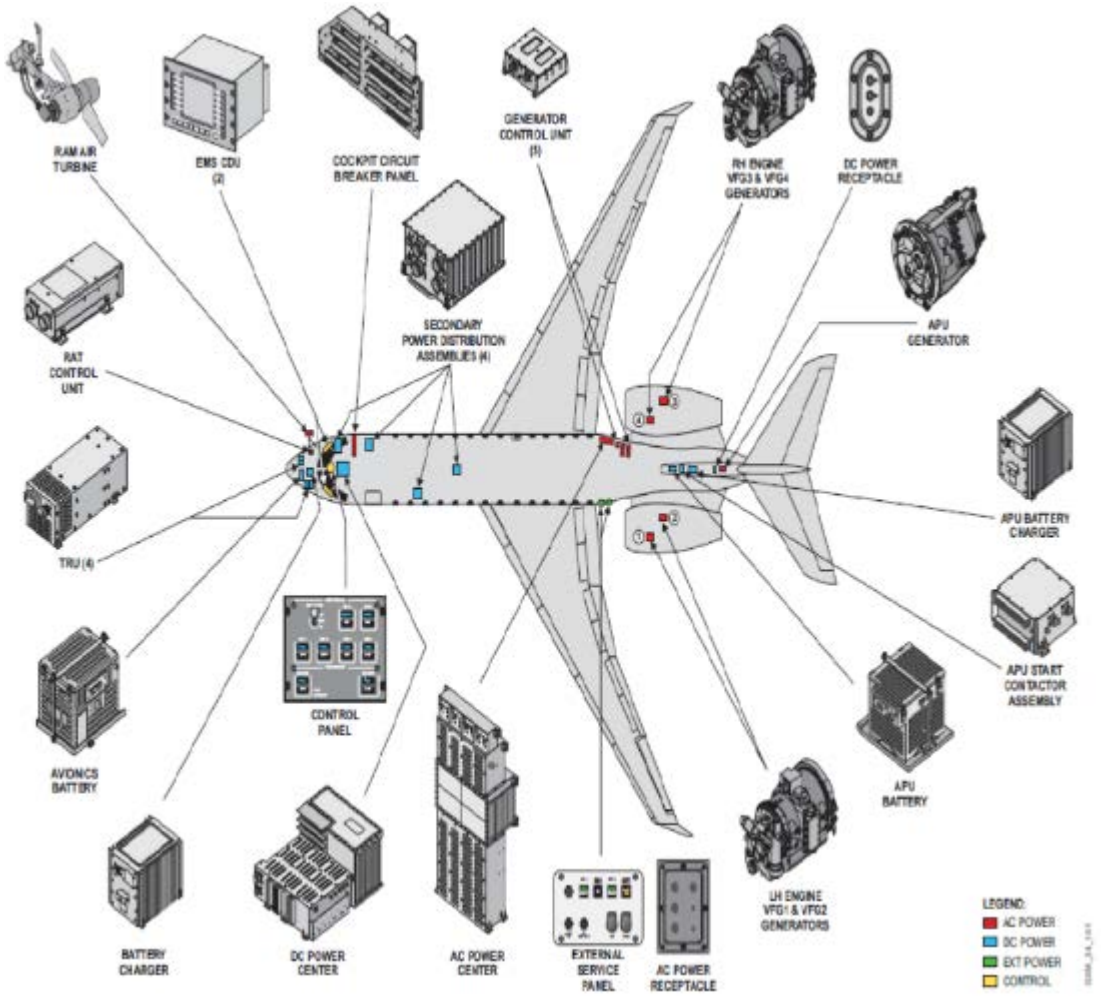
- Fully digital simulators for MIL, RCP, HIL, PHIL
- Leader in Power Electronics, Electrical Drives and Power Systems applications
- Integrated with MATLAB/SIMULINK
- COTS HW and SW based
- Compatible with Software Industry standards

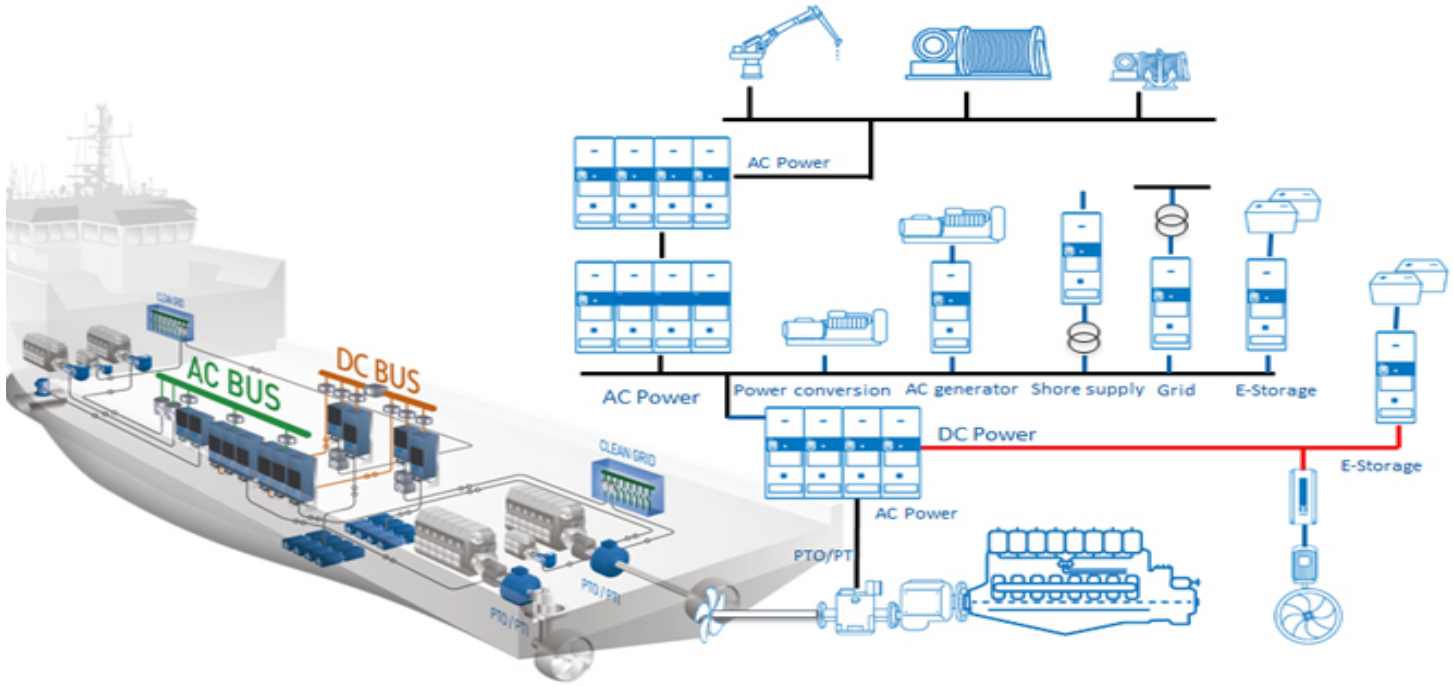
Why Power Electronics Real-time Simulation, Verification and Validation

- Early design validation
  - Simulation + Prototyping
- Testing on the real system is not always practical
- Reduce the risk of damaging equipment while testing
- Software regression testing
- Faster time to market & improved reliability

“Sorry, the controller was not tested to handle IGBT failure…!”

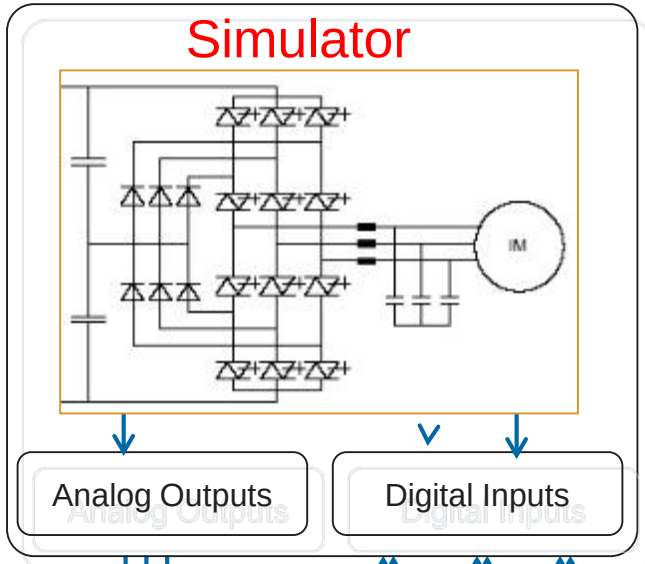
On Board Power System Overview





Application Example – HIL Testing and RCP Testing

- Testing the controller against a virtual system



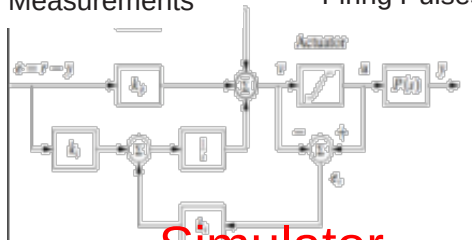
Measurements
Firing Pulses

Controller

Measurements
Firing Pulses

Controller

Analog Inputs
Digital Outputs
Measurements
Firing Pulses

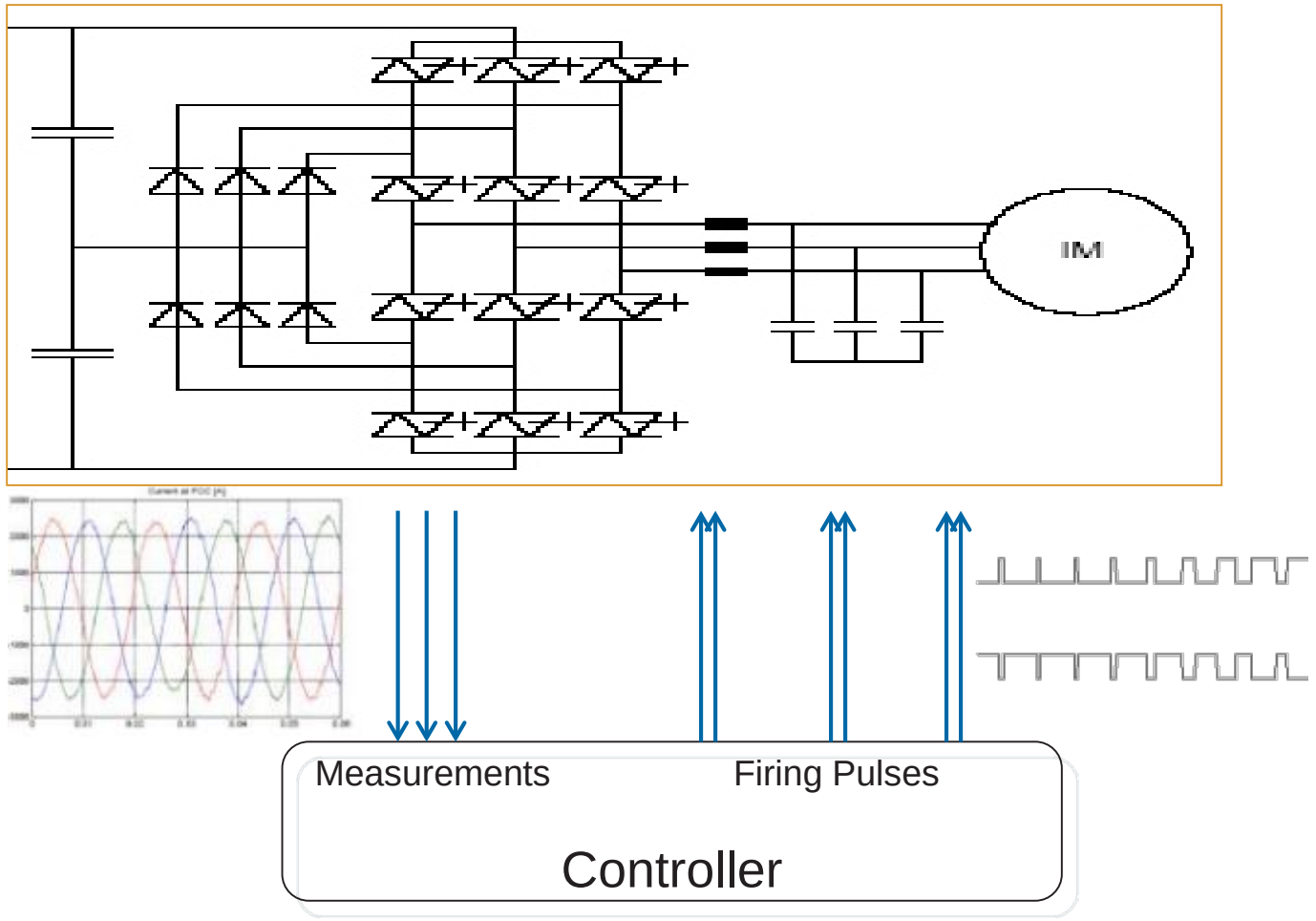


Simulator

Control Logic

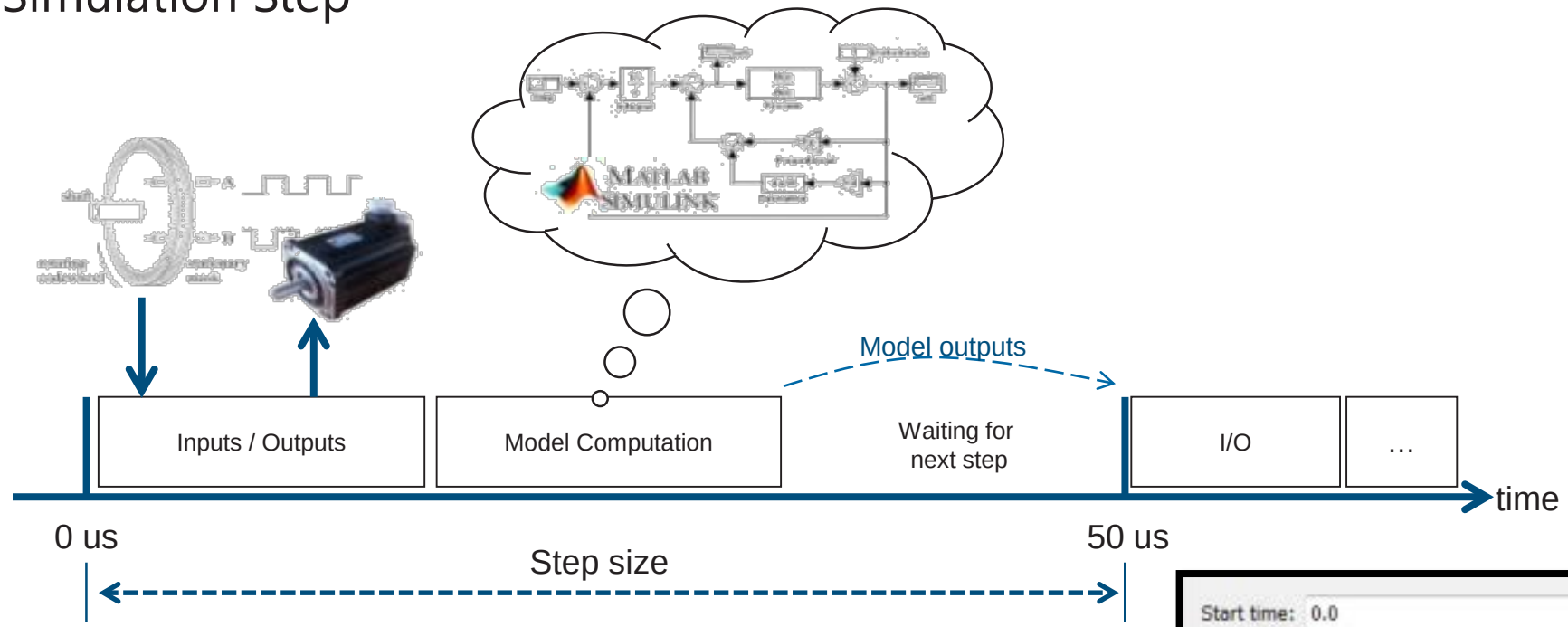
HIL Application Example

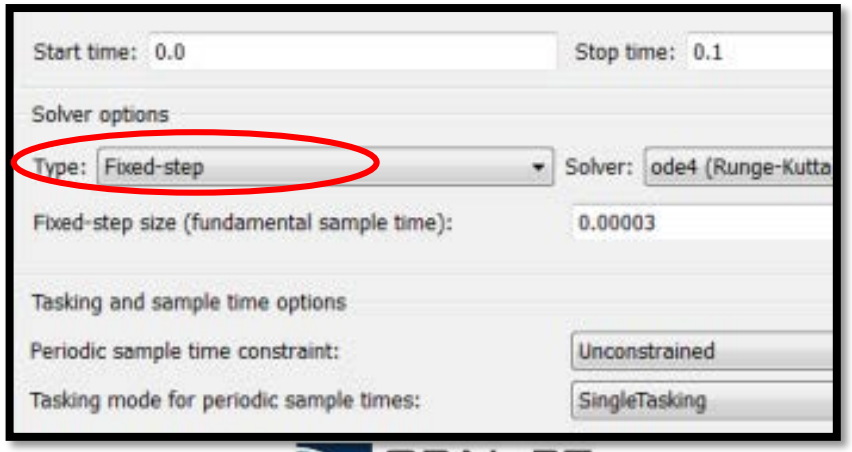
- Designing & testing a power electronics controller



Fixed-Step Computing for Real-Time

- A Typical Simulation Step





- Execution must be deterministic
- Simulation must be as real as possible
- Simulation time must follow the “real time”
- Controllers expects a precise I/O update

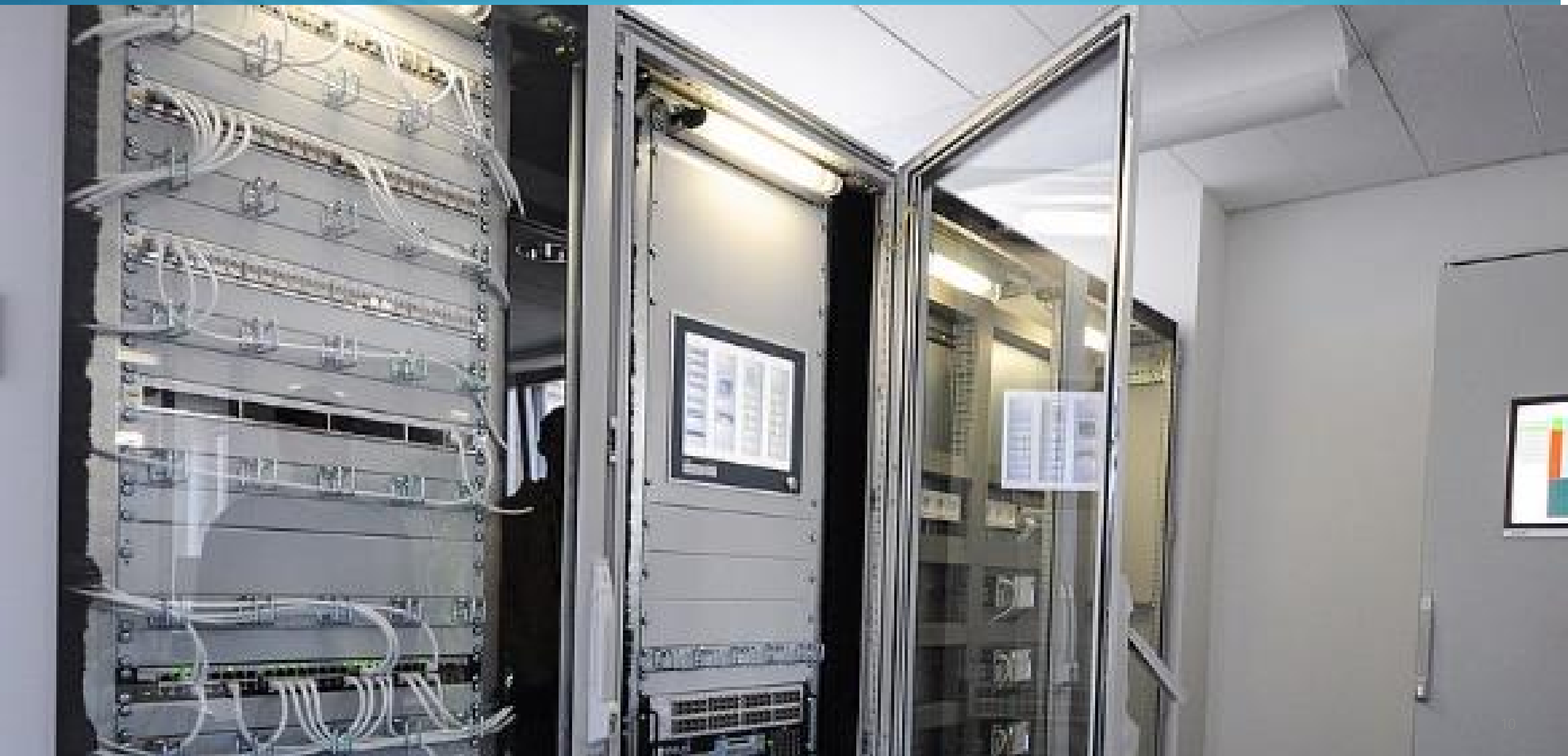
Challenges of Electric Marine World and More Electrical Aircraft

- Integration of new converter topologies into the ship / MEA on-board system
- Complex control laws for the optimal control of electrical systems *(converters, electrical machines, …)*
- New measuring and protection devices: sophisticated and communicating
- Helping academic and industrial researchers to develop innovative electrical systems

Tests and Validation

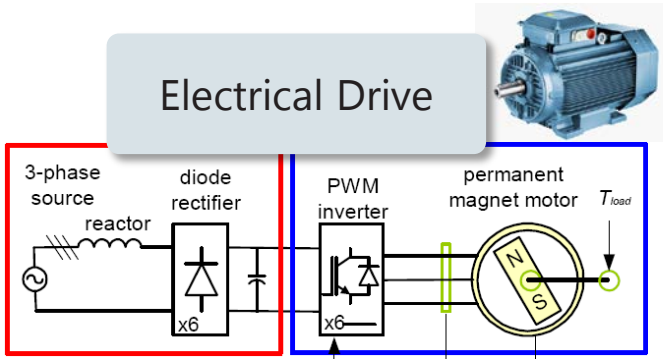
- Real-time simulation → best way to test and validate these converters
- Instead of a physical prototype → a virtual replica of an airplane or ship's on-board power supply equipped with power converters
- Simulation makes possible the emulation of detailed converter operations to test and validate different control systems

3. REAL-TIME SIMULATION: BENEFITS

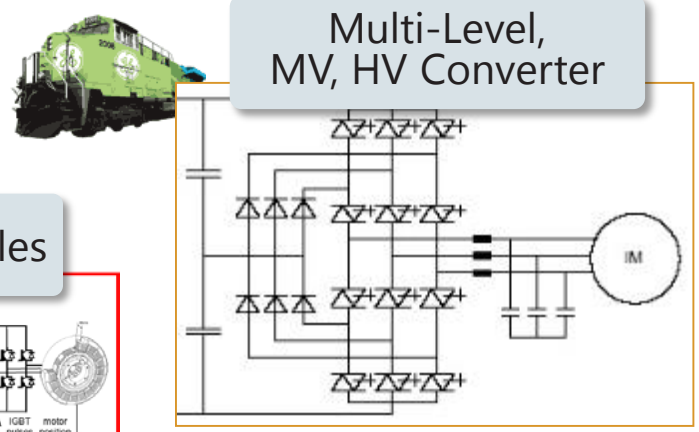


Drive Applications

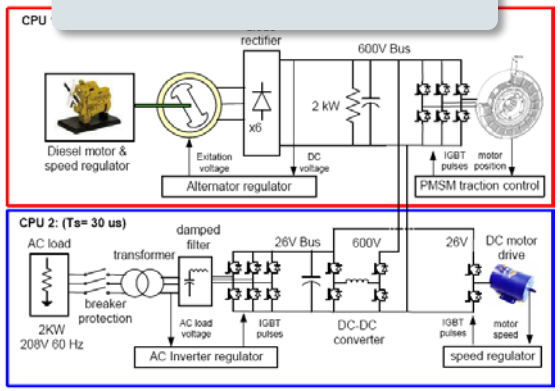
Electrical Drive



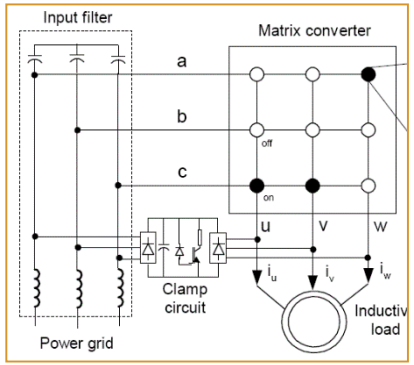
Multi-Level, MV, HV Converter



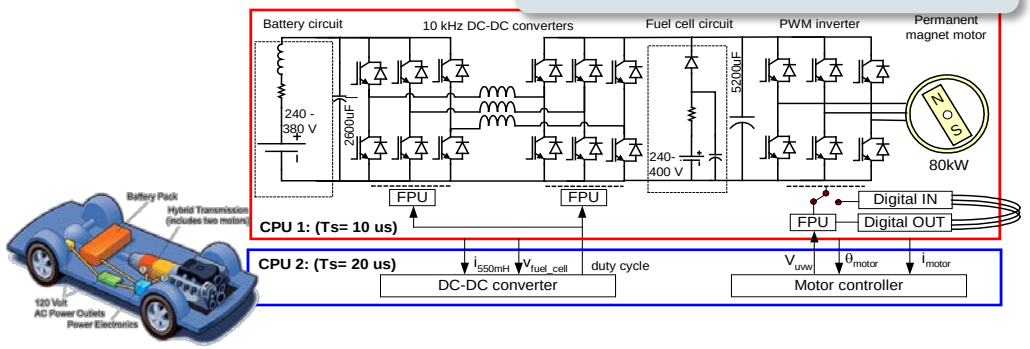
"All Electrical" Vehicles



AC-DC, DC-AC, DC-DC Power Converter



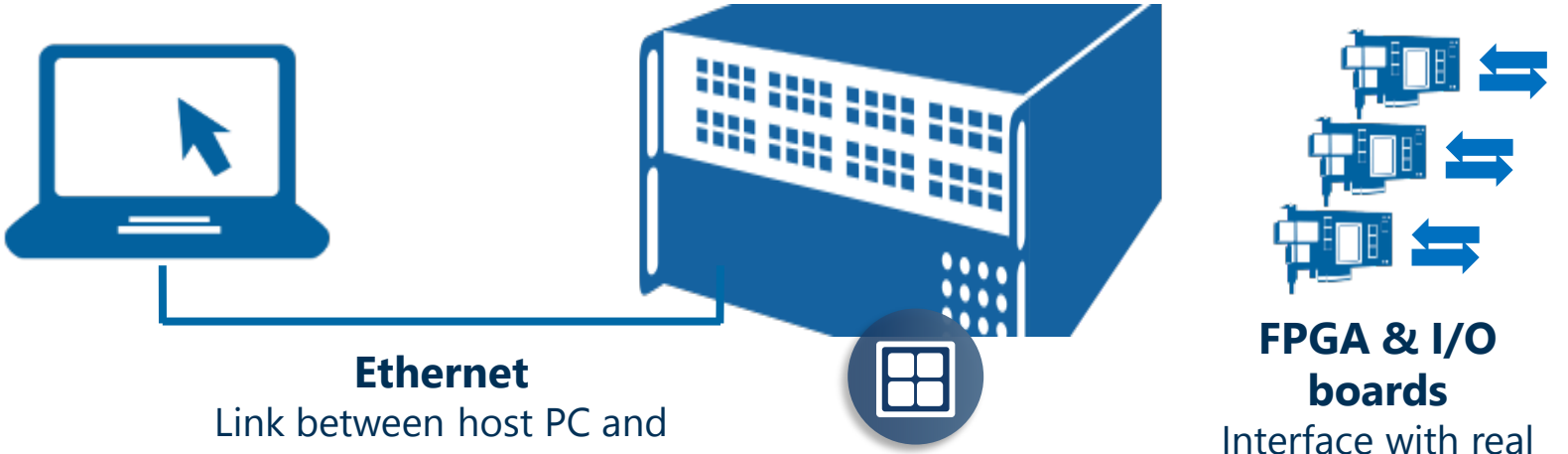
EV/HEV/PHEV/Fuel Cell Energy Storage Systems



Hardware: Real-time Simulators

Host PC
Model Edition
Simulation management
Graphical interface

RT Simulator
Model Execution
Data logging
I/O management

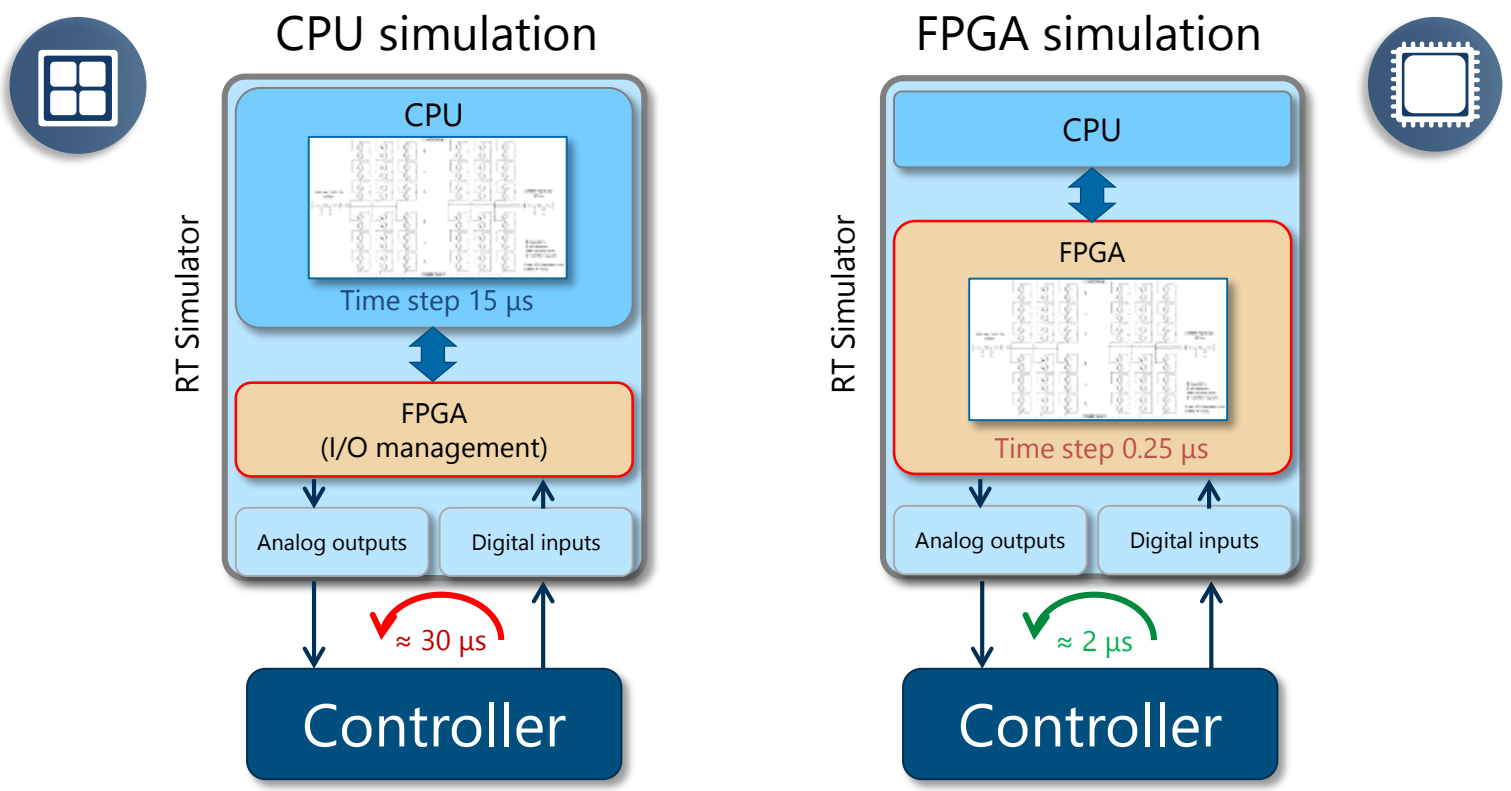


Ethernet
Link between host PC and simulator

Multiple-core CPU
Model computation

FPGA & I/O boards
Interface with real devices

FPGA simulation



Conclusion

- News laws aiming at reducing polluting emissions will force ships and aircraft to be more and more electrical
- Increasingly complex and numerous power converters
- Testing and validation through real-time simulation is essential
  - CPU simulation with SSN for decoupling the model without artificial delay
  - FPGA simulation with eHS to make it more user-friendly and performant

Thank you for your attention

Questions?

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