

DRAFT



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Virtual Electric Machine

Inertia emulation in ABB's ACS6080 Grid Simulator for special applications

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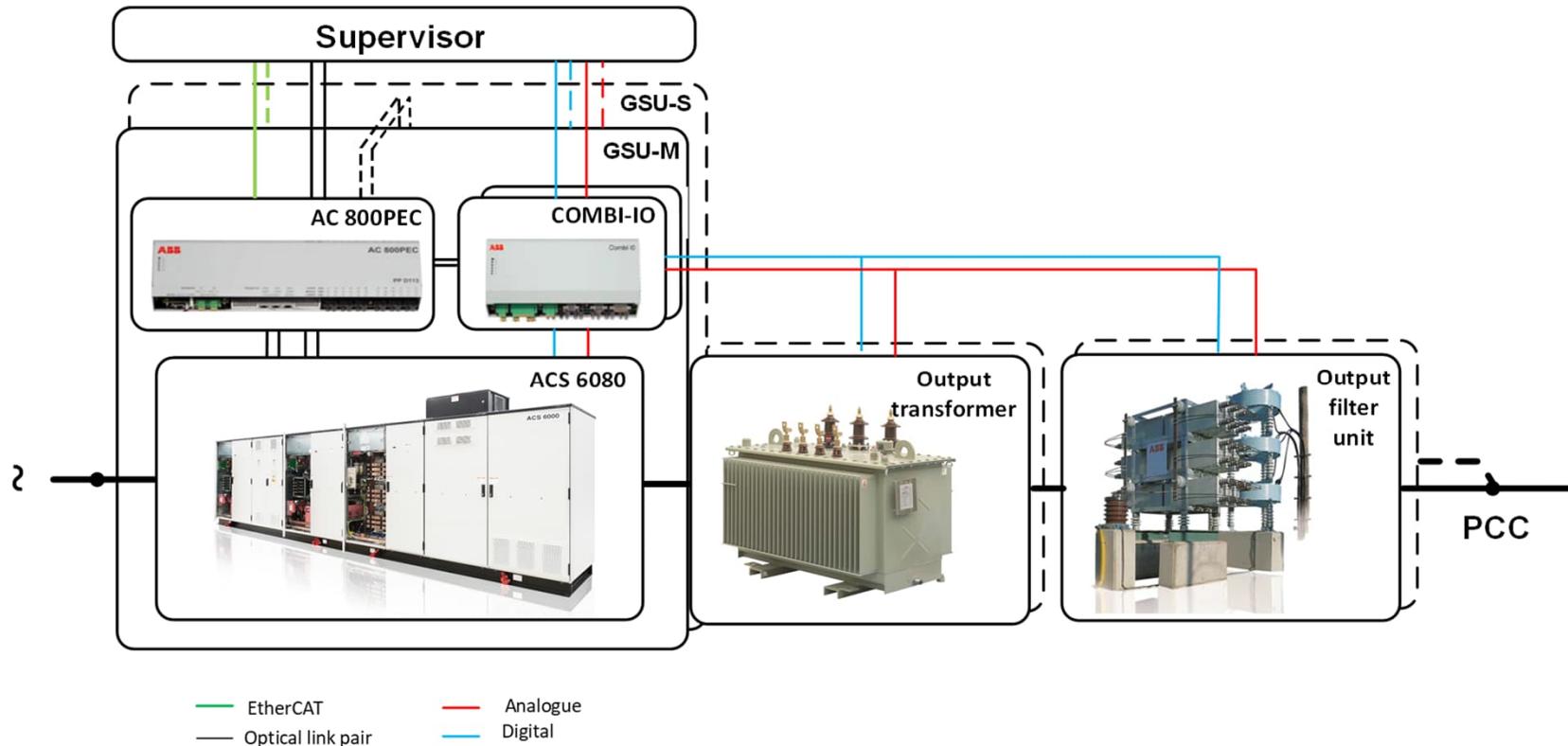
Virtual electric machine

Agenda

- ABB's Power Electronic Grid Simulator: Overview
- Virtual Electric Machine: Application vision
- Electric machine emulation principle
- Synchronous generator emulator example
- Summary

ABB's Power Electronic Grid Simulator

Overview



- Controllable grid interface to support activities focused on testing and certification of inverter-coupled renewable energy technologies and their integration to the power system
- **High performance high-power range medium voltage source for special applications**

GSU-M – main grid simulator unit:

ACS6080 – ABB's MV converter;

AC 800PEC – main application controller;

CombiIO – A/D signals processing devices.

GSU-S – slave grid simulator unit

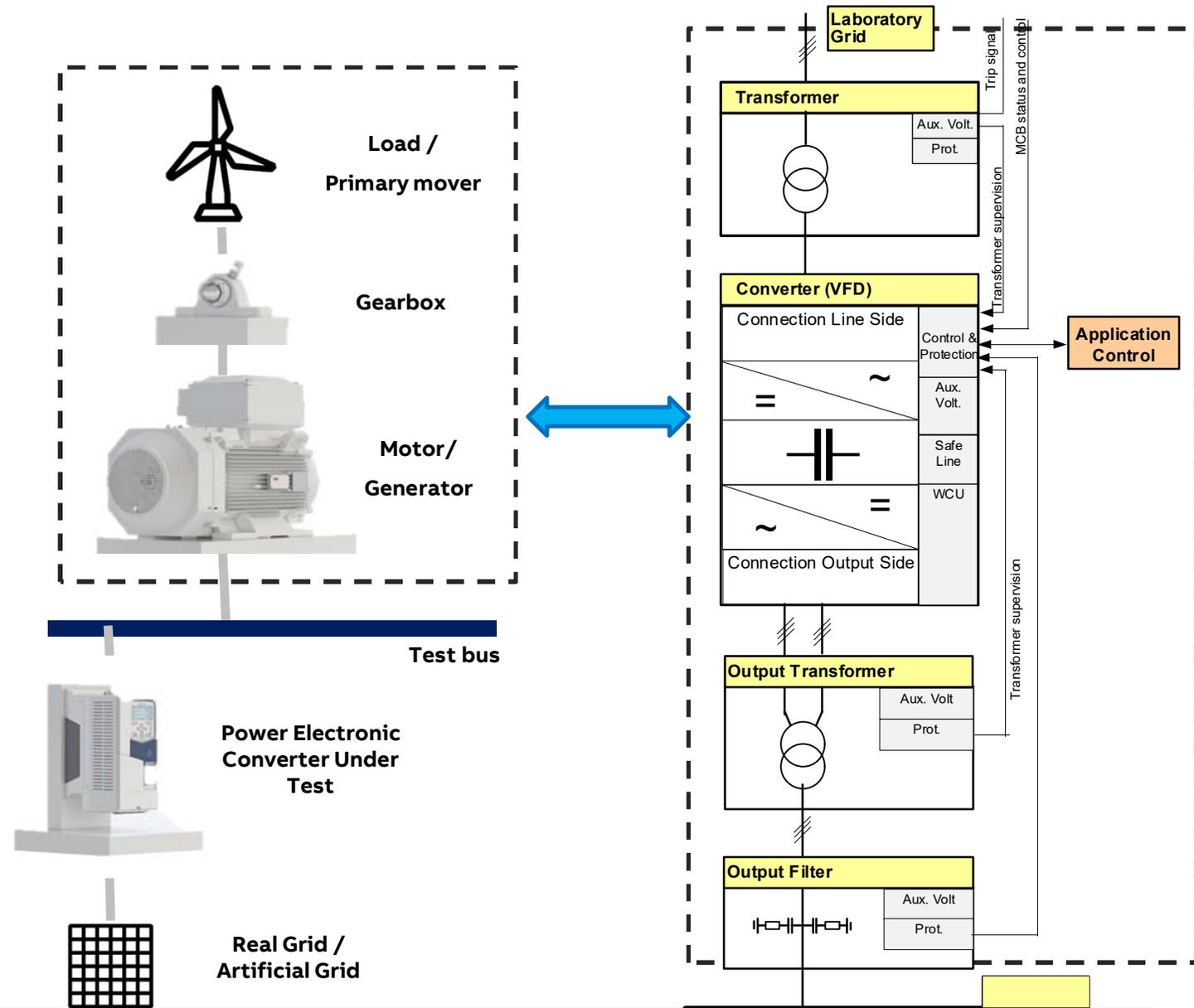
(extended power applications);

PCC – point of common coupling (test bus)

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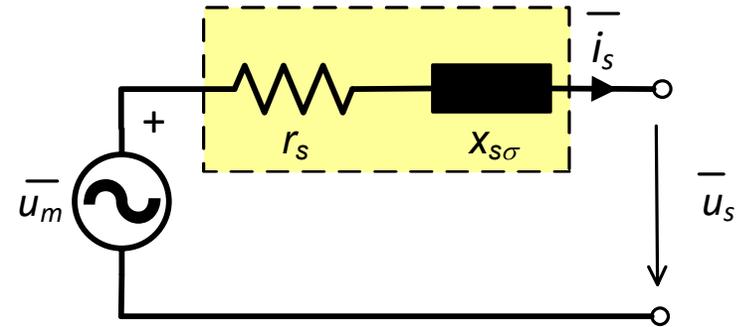
Application vision

- Power Electronic Grid Simulator is controlled with special algorithm to emulate operational characteristics and transients of electric machine [in certain frequency range]
- Areas of application:
 - testing of the power electronic converters for motor-based or generator-based applications;
 - studies of electrical processes in the power systems with components characterized by the different sorts of inertia.



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Electric machine emulation principle



u_m – emulated internal voltage;

i_s – virtual machine current;

u_s – voltage on virtual machine terminals seen from test bus;

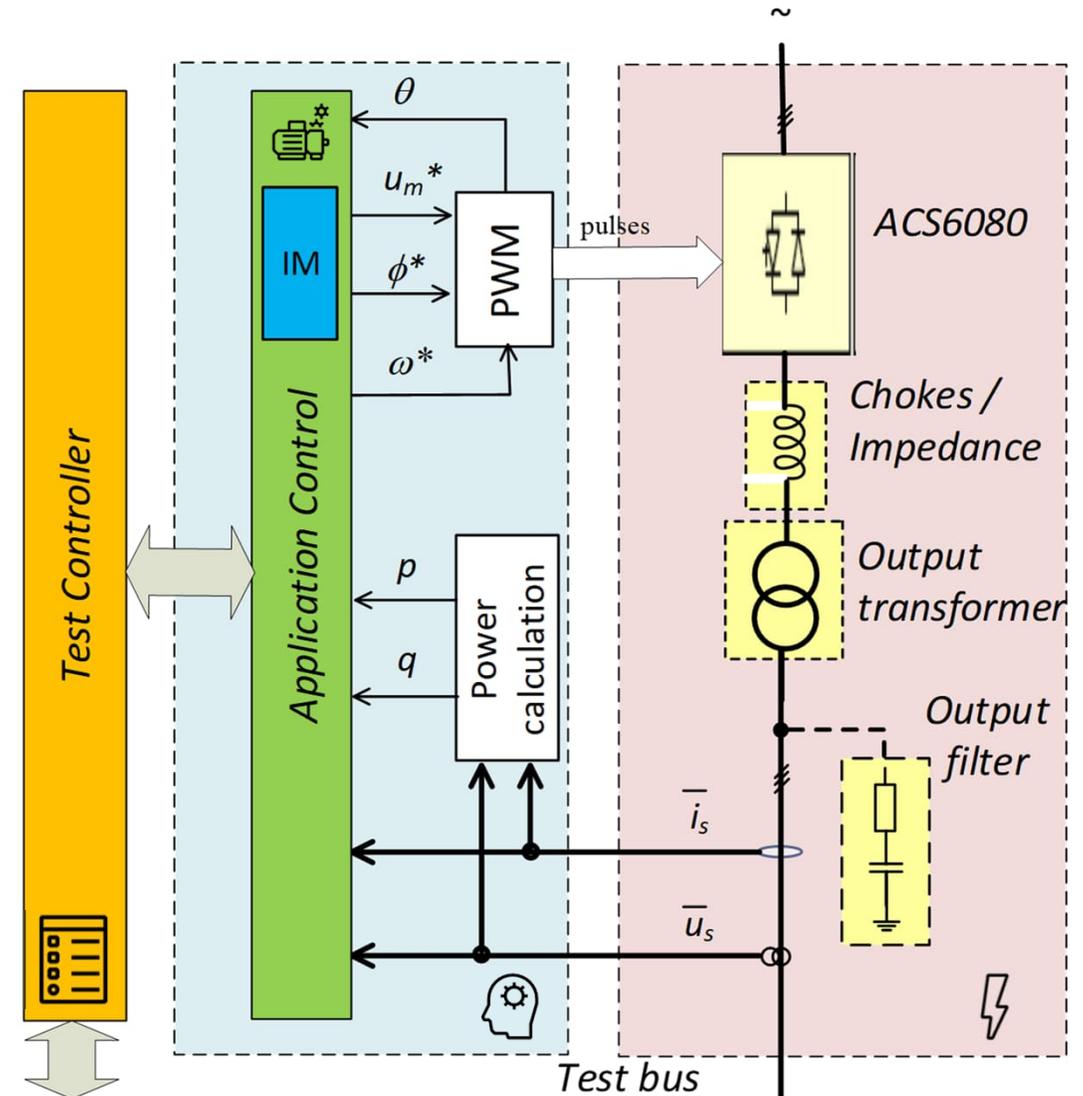
$r_s, X_{s\sigma}$ – resistance and reactance of stationary winding (virtual or physical)

Electric machine is essentially a voltage source with internal impedance

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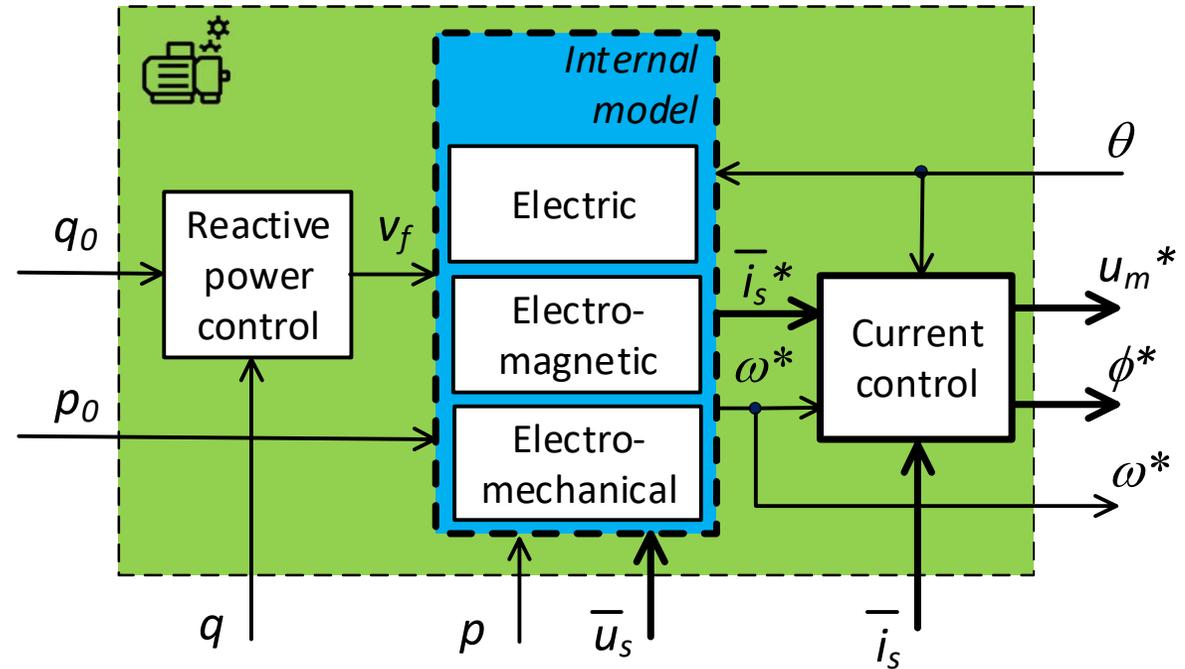
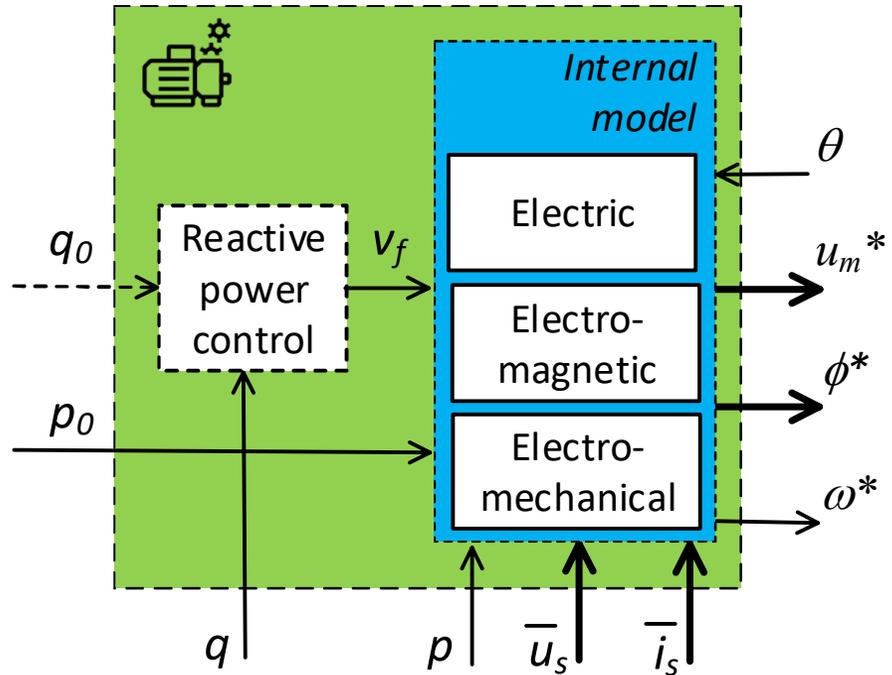
Control diagram

- Power unit is customized, represents machine winding connected to the test bus;
- Internal voltage of machine is defined by pulse pattern provided by application control (with main harmonic component AC or DC);
- Processes seen from the test bus are similar to the processes in real machine;
- Main application controller realizes modulation strategy and main application control functionalities, including model of electric machine
- High-level advanced test controller implements global test scenario
- External controller for advanced functionalities (option)



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Application control: Synchronous generator emulation example

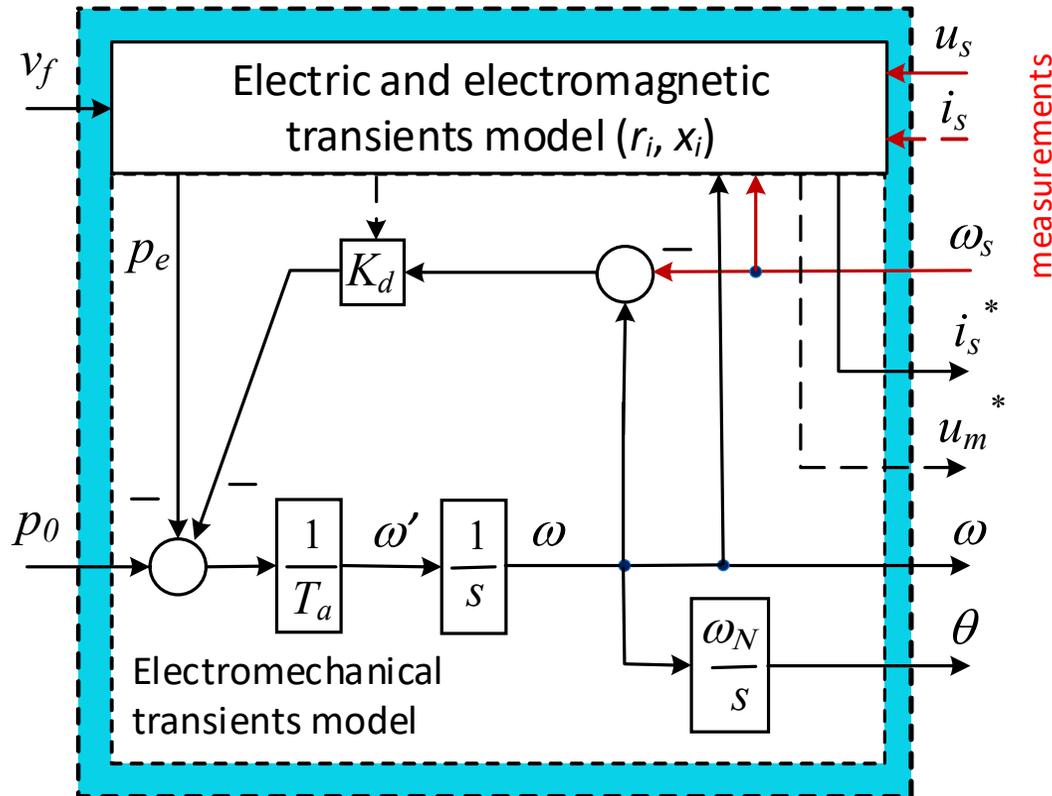


- Two basic concepts* at the background:
 - Voltage source (Synchronverter)
 - Current source (Virtual machine)
- Emulation of various control schemes

- Reconstruction of inertial processes with internal model:
 - electromechanical – power and frequency control;
 - electromagnetic – control of internal voltage;
 - electric – fast transients in output voltage and current.

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Internal model



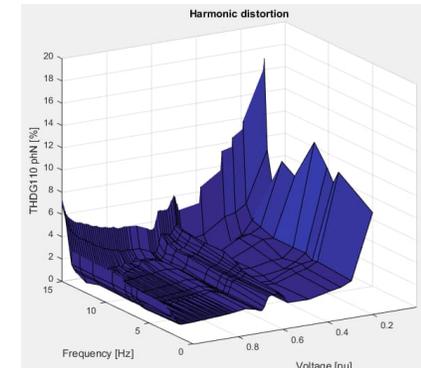
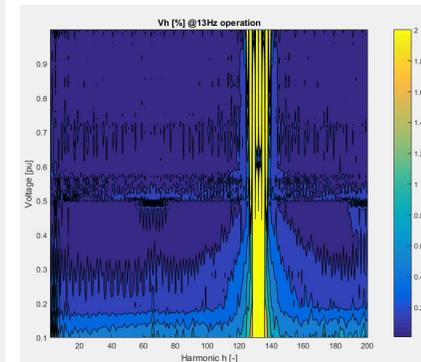
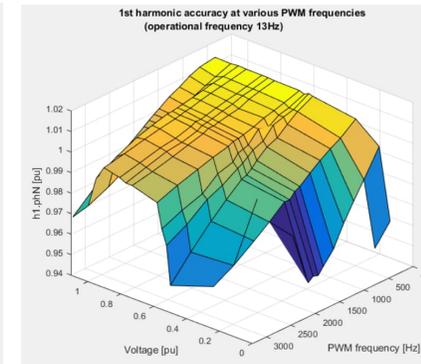
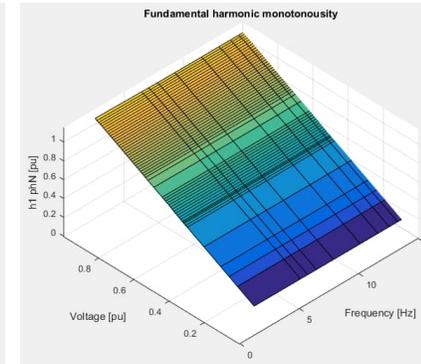
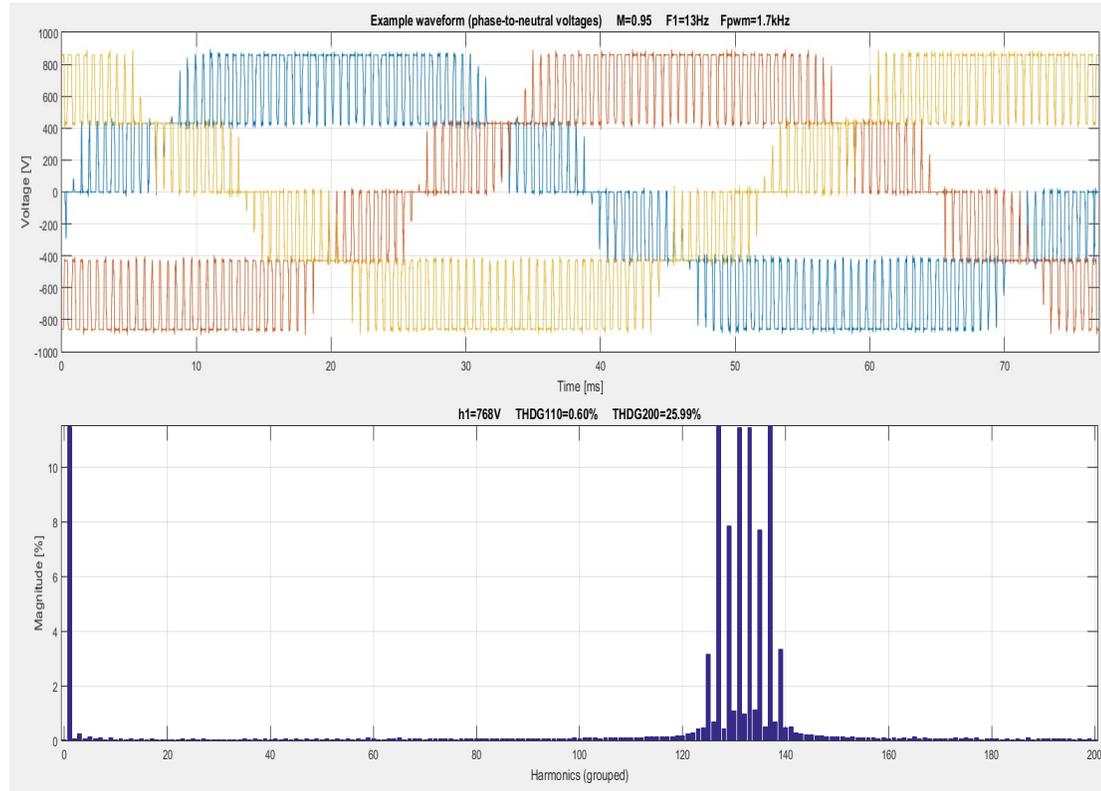
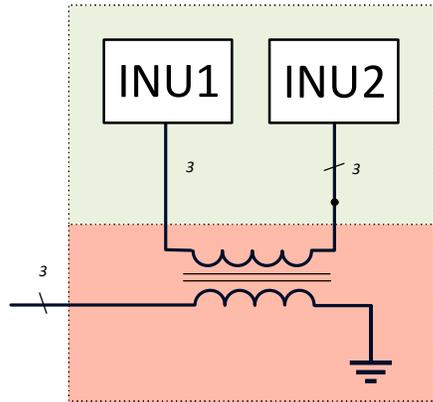
- ❑ Focus on processes of interest
- ❑ Equations are solved in real time by means of:
 - internal and external* application control;
 - customized programmable area (future releases).
- ❑ Flexible implementation and parametrization – allows to cover machines of different powers ranges and types
- ❑ Each process is to be emulated with the core [parametrizable] equation and/or with component provided from the external control*

* additional application controller or HIL simulator with use of real-time communication interfaces to the main controller

Synchronous generator emulator example

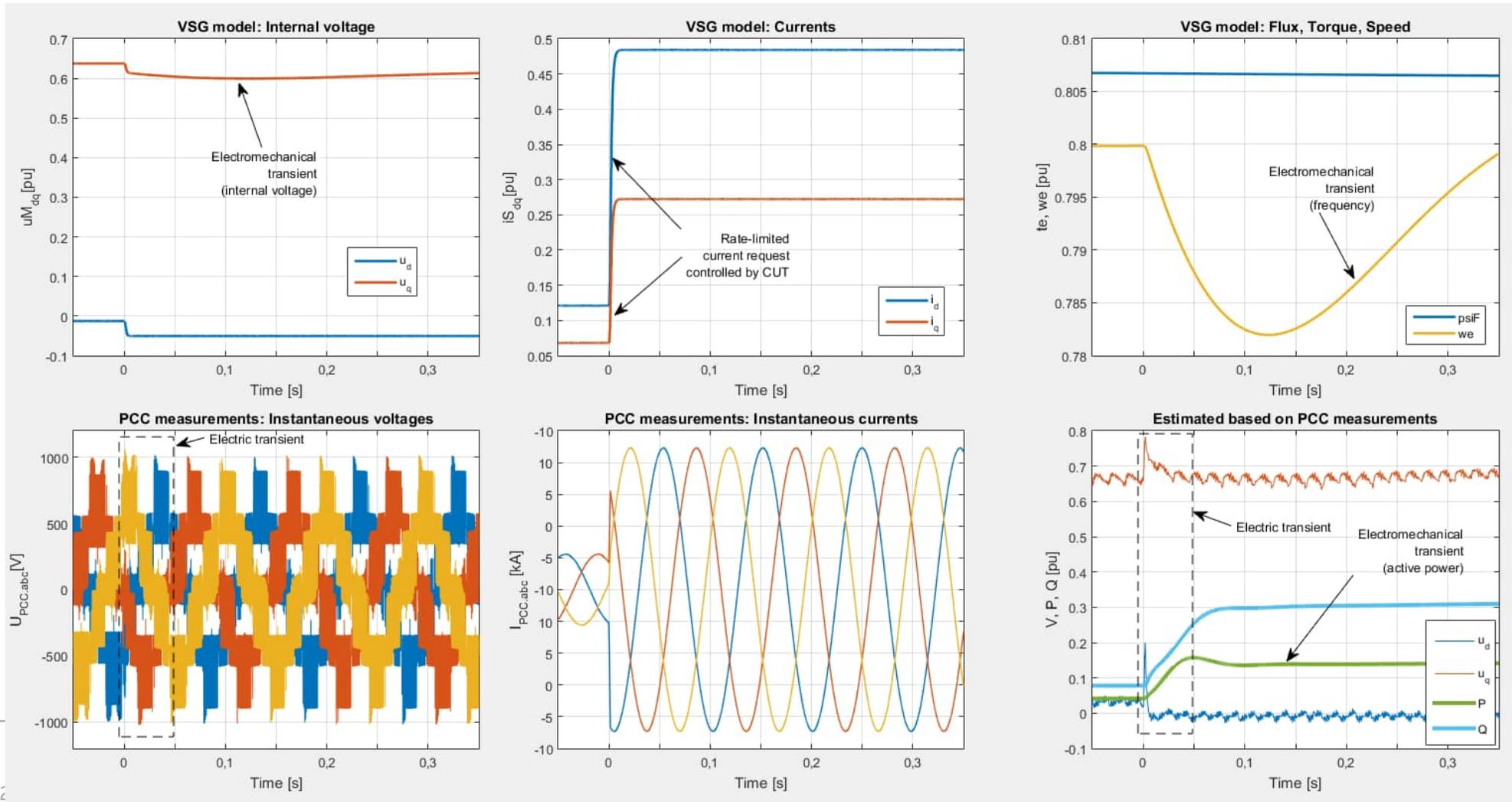
Example voltage waveform and basic pattern quality in operational range

Single-FB converter



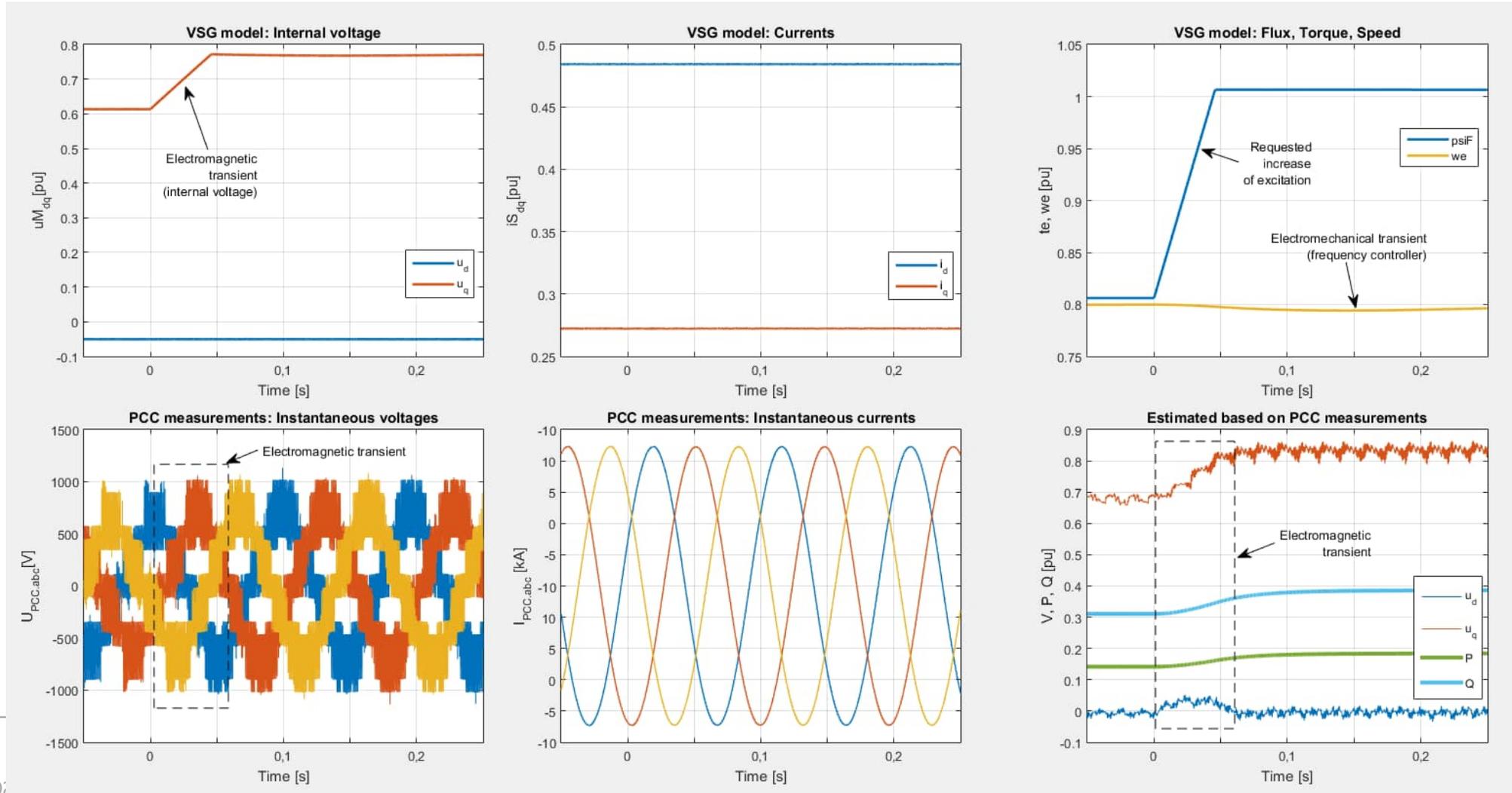
Synchronous generator emulator example

Example of transients emulation: Power demand increase



Synchronous generator emulator example

Example of transients emulation: Excitation increase



Virtual electric machine based on ABB's ACS6080 Grid Simulator

Summary

- Described control solution supports multi-MVA range special applications with emulation of transients originated from different sources (such as motors and generators), as well as operational characteristics of such plants, with output voltage frequency in wide range (from 0 to 67Hz and higher)
- Virtual electric machine control:
 - emulation of electric machines of different types and power ranges, including DC;
 - realized based on high-performance application controller;
 - supports real-time interfaces to external controllers with small latency time;
 - allows processes emulation using model in internal customized programmed area of main application controller (future releases)

ABB