AIT Austrian Institute of Technology

4DIAC for Smart Grids Applications

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W3 Second 4DIAC User's Workshop (4DIAC)

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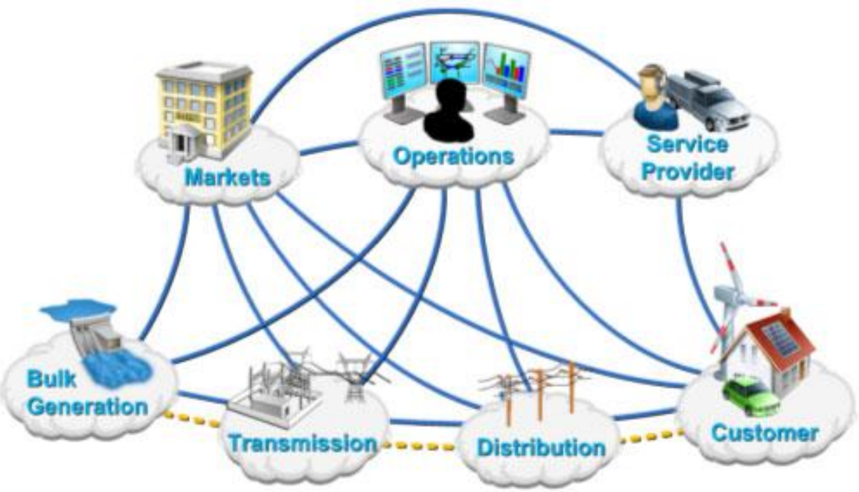
Introduction / Motivation

Usage of IEC 61499 / 4DIAC for Smart Grids Applications?

- High efforts are spent to modernize the electrical grids → transformation into "Smart Grids"
- According to the IEC Smart Grids roadmap intelligent devices are necessary for realizing Smart Grids
- Standard-based implementation is a key requirement for future developments
- Usage of distributed automation concepts for controlling electrical power systems
- Open source strategy and open standards as driver to push new developments for power & energy systems
- Well supported open source tools available (4DIAC, PSAT, etc.)

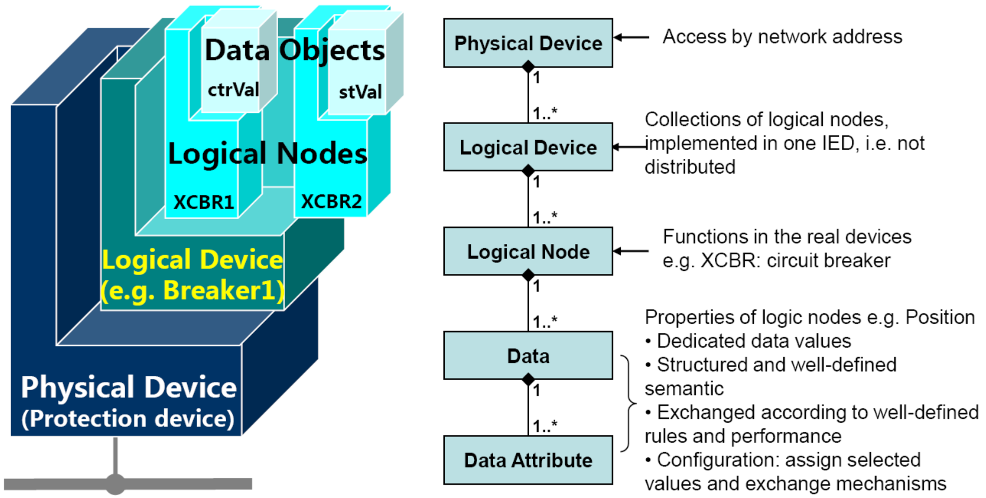


Smart Grid conceptual model - adding intelligence to various parts of the network (Source: IEC Strategic Group 3 (SG3))

IEC 61850 Integration into IEC 61499 FBs

Standard Compliant Representation of Intelligent Electronic Devices (IED)

- IEC 61850 – Power Utility Automation
  - Interoperability standard for communication networks and systems for power utility automation
  - Standardization of the information model and how the information should be transferred between devices
  - Covers modeling, configuration and communication
  - Object-oriented approach
  - Definition of logical devices and logical nodes
  - XML-based system configuration language (SCL)
  - Implementation of device functions not covered

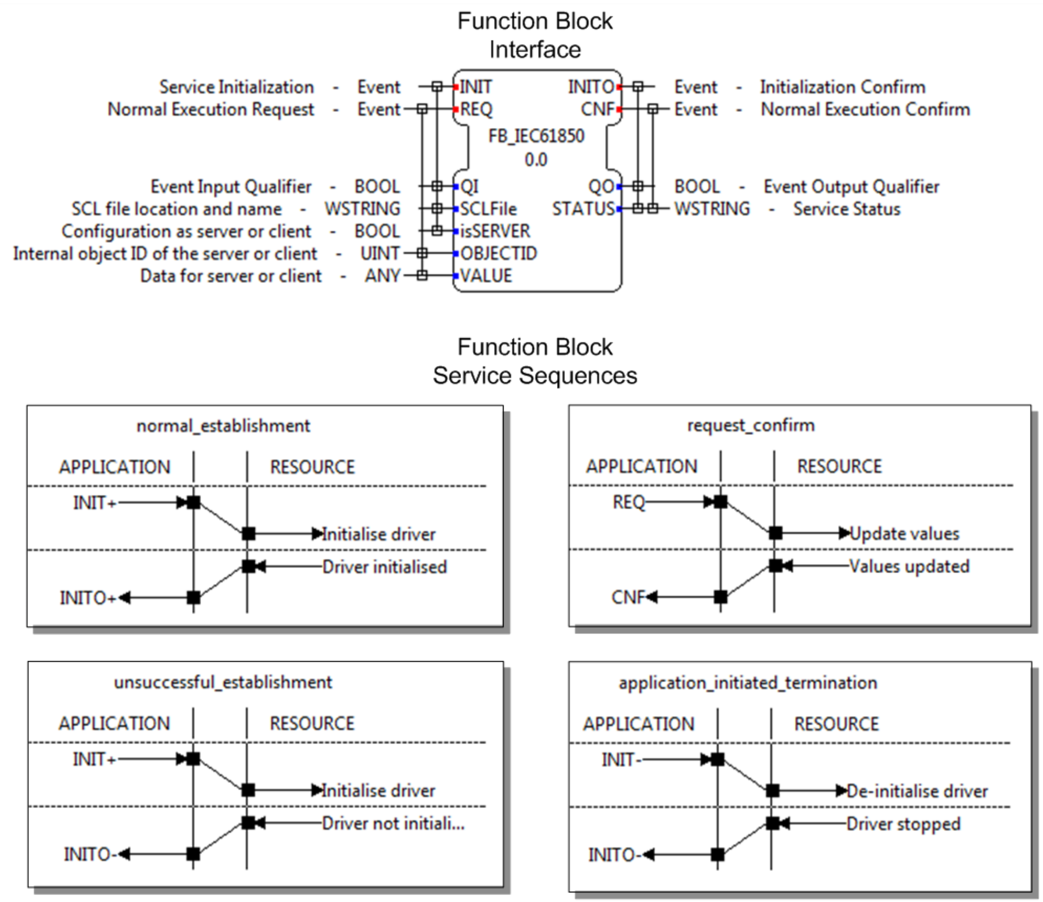


Source: IEC

IEC 61850 Integration into IEC 61499 FBs

Standard Compliant Representation of Intelligent Electronic Devices (IED)

- As IEC 61499 service interface function block
- Usage of the SystemCorp IEC 61850 stack
  - Industrial PC implementation
  - Beck IPC@Chip implementation
- Windows-based implementation (DLL)



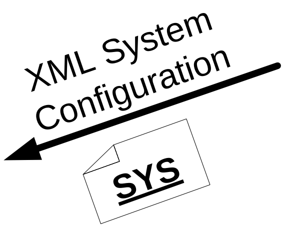
IEC 61850 Integration into IEC 61499 FBs

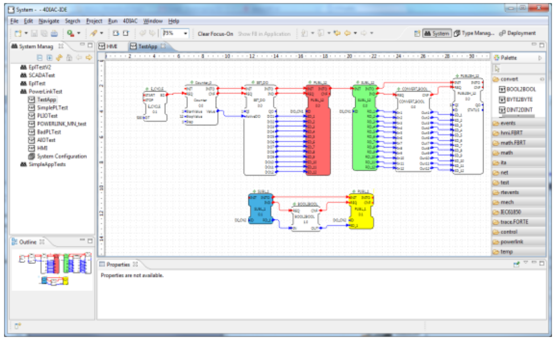
Standard Compliant Representation of Intelligent Electronic Devices (IED)

- Necessary Tools/Software
  - IED Configuration Tool (e.g. IEDScout)
  - IEC 61850 Stack (e.g. SystemCorp)
  - 4DIAC-IDE
  - FORTE

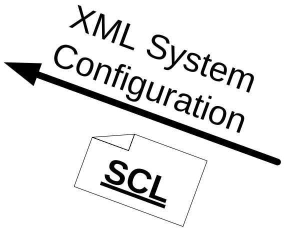
4DIAC
Framework for Distributed Industrial Automation and Control

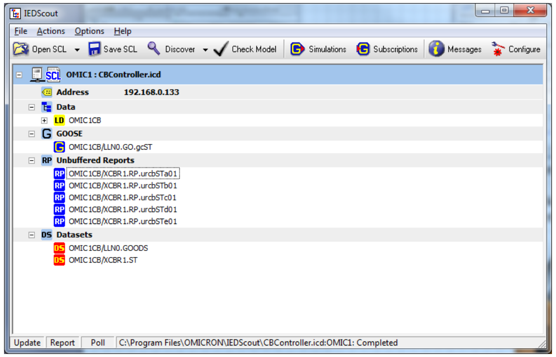
Intelligent Electronic Device (IED)





4DIAC-IDE



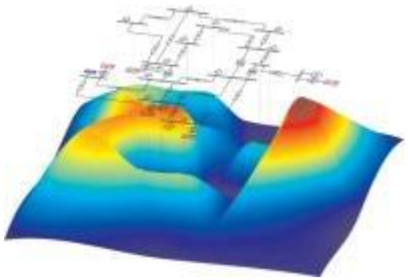


OMICRON IEDScout

Co-Simulation Electrical Networks and Control Applications

Power Systems Simulation and Control with GNU Octave/PSAT and 4DIAC

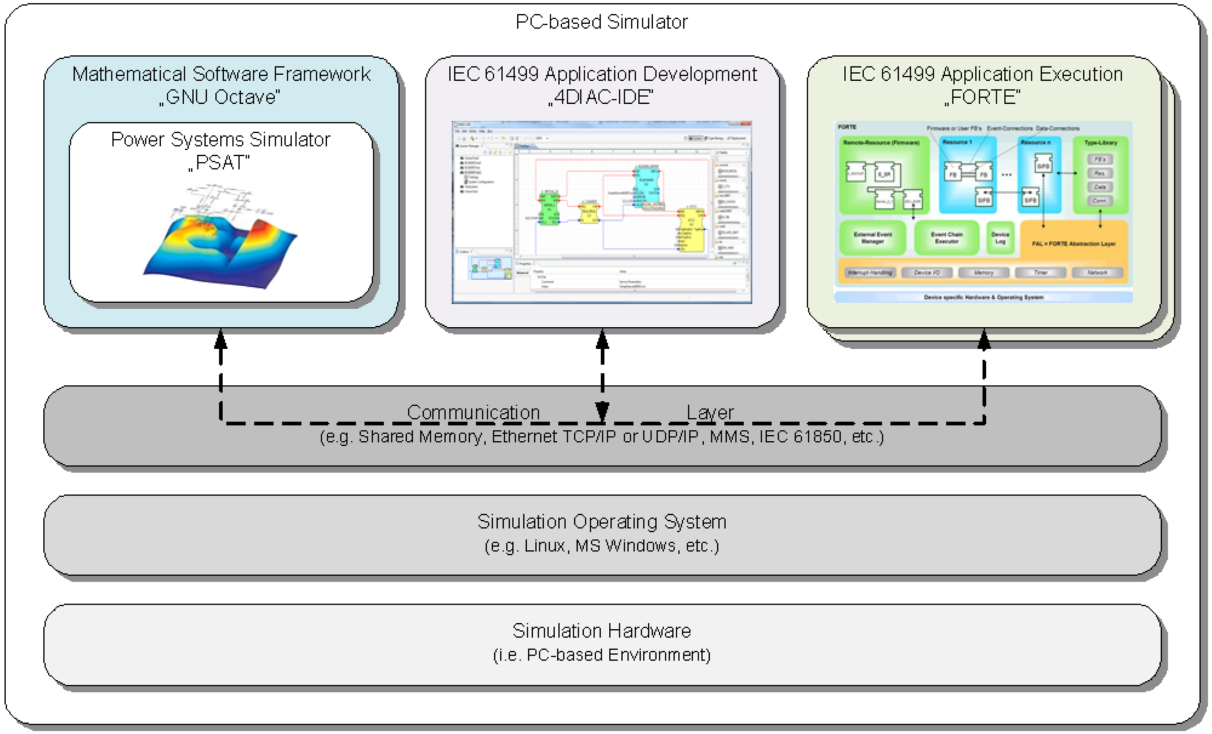
- GNU Octave
  - Environment for numerical computations
  - High-level language (mostly compatible with Matlab)
  - Provided under the GNU General Public License (GPL)
- Power System Analysis Toolbox (PSAT)
  - Analysis of electric power systems
    - Power, continuation power and optimal power flow calculations
    - Signal stability analysis
  - Provided under the GNU General Public License (GPL) for Matlab/Simulink and GNU Octave



Co-Simulation Electrical Networks and Control Applications

Power Systems Simulation and Control with GNU Octave/PSAT and 4DIAC

- Architecture

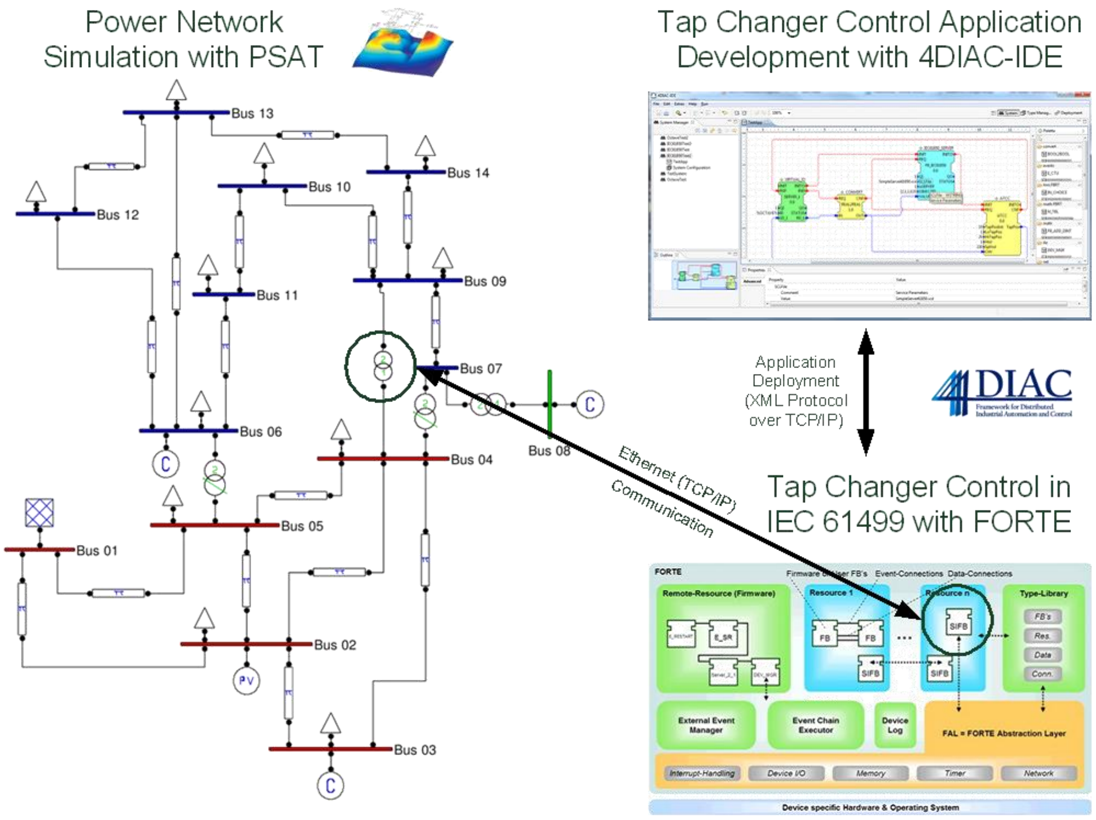


Source: T. Strasser, M. Stifter, F. Andren, D. Burnier de Castro, and W. Hribernik, Applying Open Standards and Open Source Software for Smart Grid Applications Simulation of Distributed Intelligent Control of Power Systems," in 2011 IEEE Power & Engineering Society (PES) General Meeting, July 24-29, Detroit, Michigan, USA, 2011.

Co-Simulation Electrical Networks and Control Applications

Power Systems Simulation and Control with GNU Octave/PSAT and 4DIAC

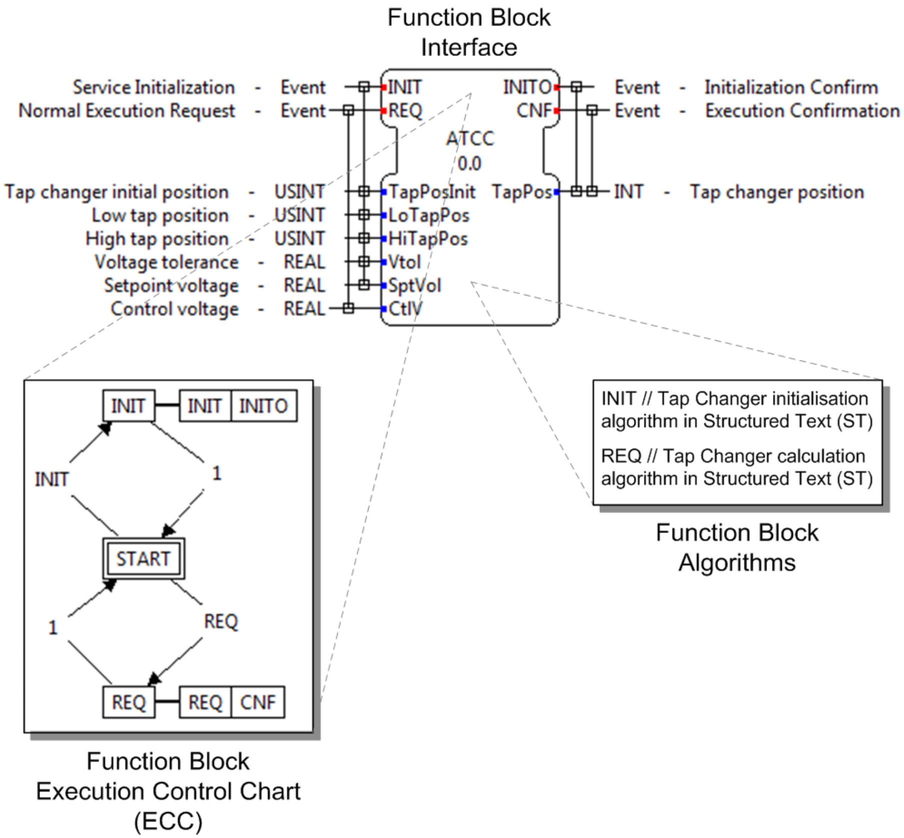
- Implemented Case Study: Under-Load Tap Changer (ULTC)



Co-Simulation Electrical Networks and Control Applications

Power Systems Simulation and Control with GNU Octave/PSAT and 4DIAC

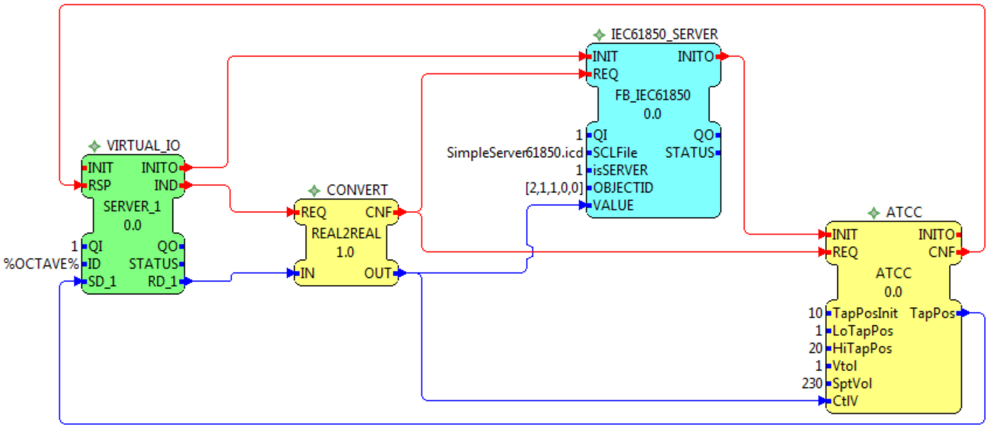
- Automatic Tap Changer Controller (ATCC) Implementation
  - As IEC 61499 basic function block
  - Algorithm implemented in Structured Text (ST)



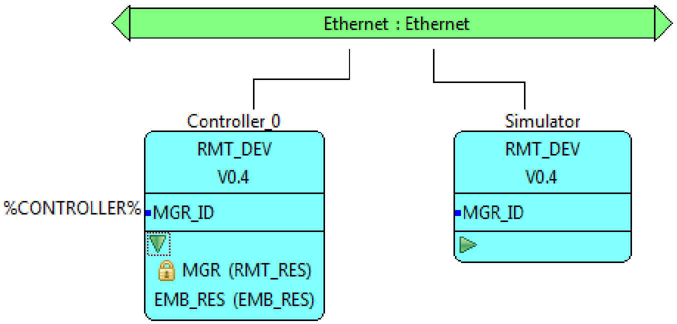
Co-Simulation Electrical Networks and Control Applications

Power Systems Simulation and Control with GNU Octave/PSAT and 4DIAC

- Application Model



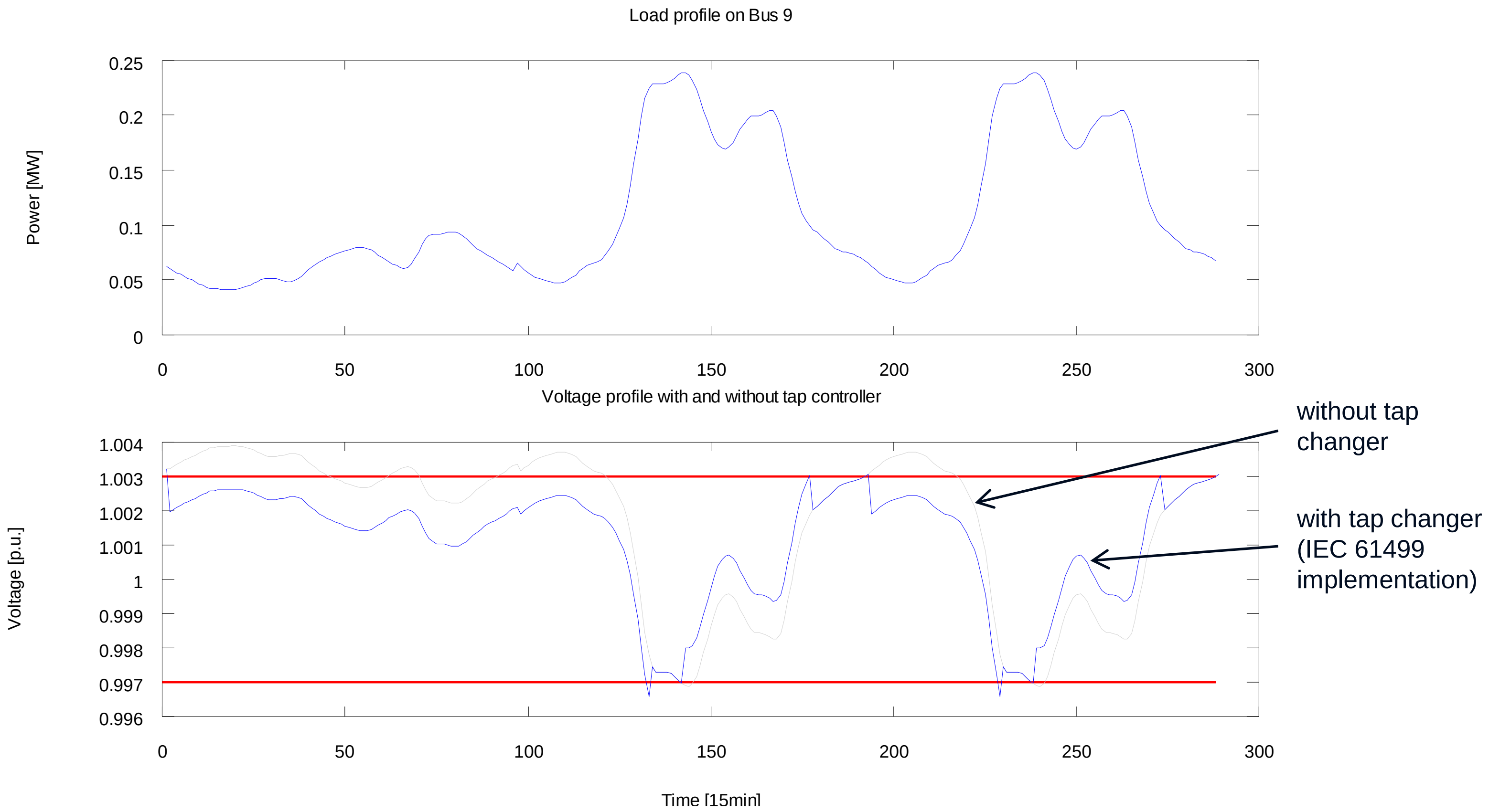
- System Configuration



Co-Simulation Electrical Networks and Control Applications

Power Systems Simulation and Control with GNU Octave/PSAT and 4DIAC

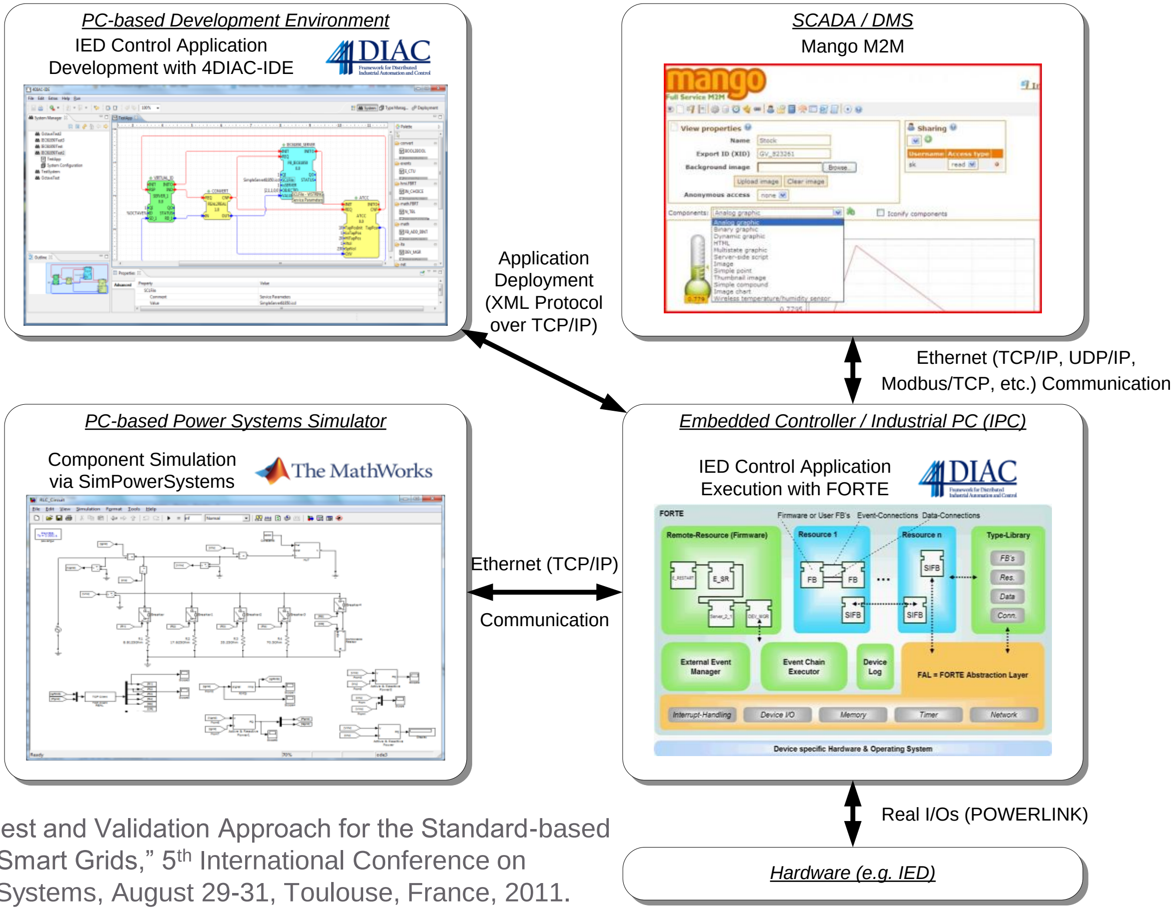
- Demo: IEC 61850 Client (IEDScout) + Control (4DIAC) + Simulation (PSAT)



AIT Laboratory Automation

Open Source-based SCADA and Control Approach

- Validation Environment for
  - IEDs
  - Automation and control strategies
  - Communication protocols and interfaces, etc.
- Free and open source tools
  - 4DIAC
  - openPOWERLINK
  - Mango M2M

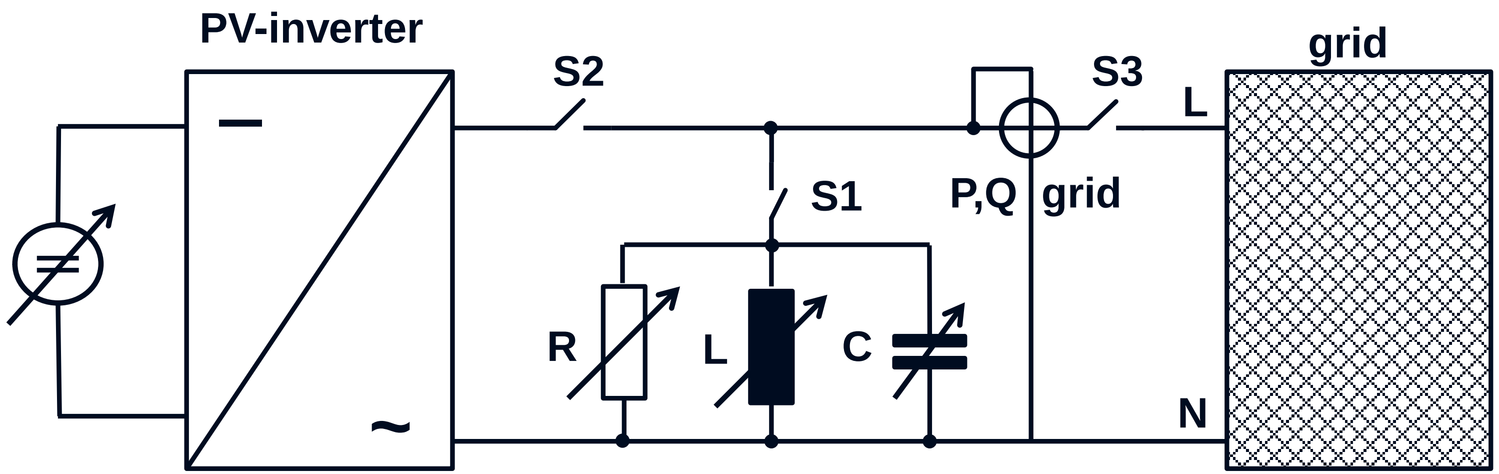


Source: T. Strasser, F. Andren, and M. Stifter, “A Test and Validation Approach for the Standard-based Implementation of Intelligent Electronic Devices in Smart Grids,” 5th International Conference on Industrial Applications of Holonic and Multi-Agent Systems, August 29-31, Toulouse, France, 2011.

AIT Laboratory Automation

Open Source-based SCADA and Control Approach

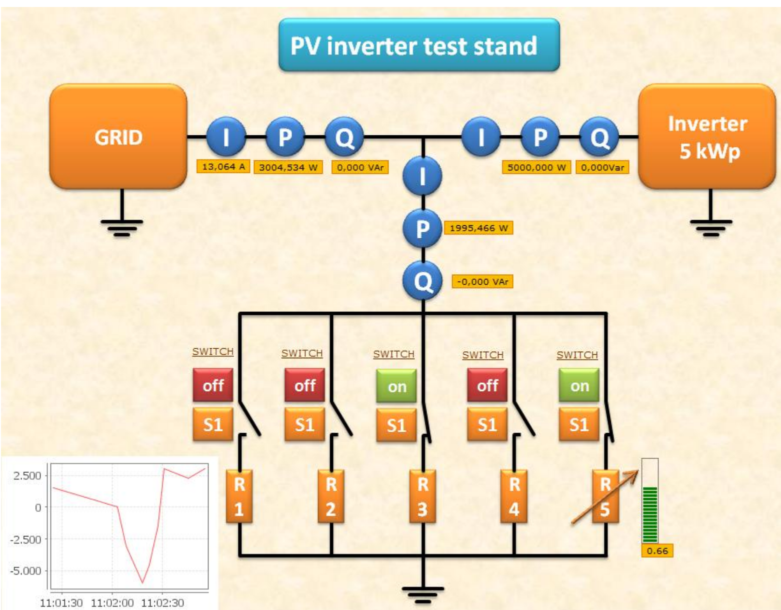
- Implemented Case Study: Control of AIT PV-inverter Test Stand
  - RLC tuning for PV-inverter islanding test (VDE 0126)

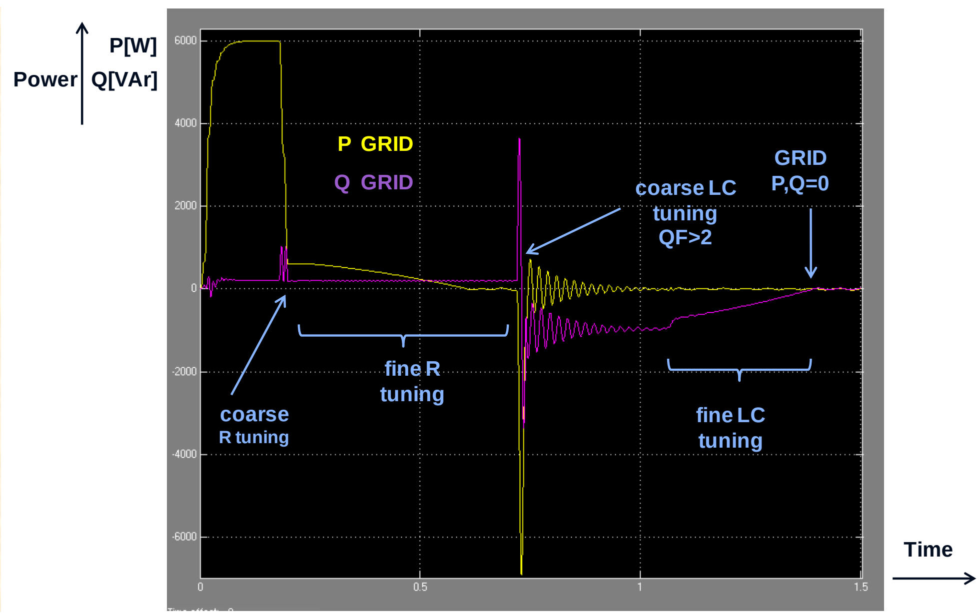


AIT Laboratory Automation

Open Source-based SCADA and Control Approach

- Implemented Case Study: Control of AIT PV-inverter Test Stand
  - Demo: SCADA-Application (Mango M2M) + Control (4DIAC) + Simulation (Simulink)

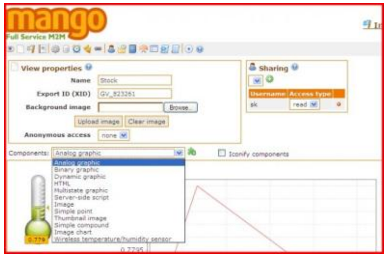


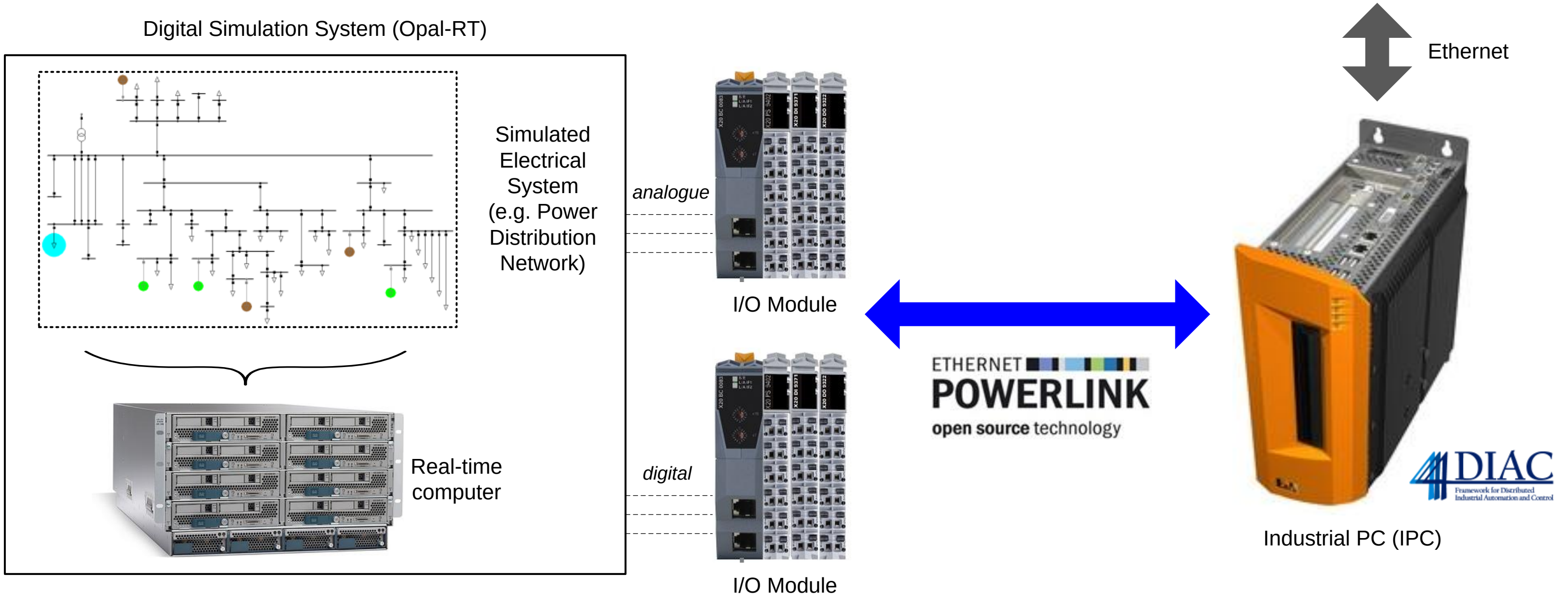


Controller-Hardware-in-the-Loop (CHIL) Tests

Standard-compliant Open Source-based Real-Time Validation Environment

- Tool Chain
  - SCADA-Application (Mango M2M)
  - Control (4DIAC) + I/O Access (openPOWERLINK)
  - Real-time Simulation (Opal-RT)





Future Activities

Plans for the upcoming months

- Development of an IEC 61499 function block library for Smart Grids applications
  - User documentation
  - Provision as 4DIAC open source module under the EPL
- Implementation of the open source-based SCADA and control approach in the AIT power distribution laboratory
- Various laboratory tests (incl. performance tests, etc.)
- Implementation of a Controller-Hardware-in-the-Loop test environment using 4DIAC
- Setup of an open-source co-simulation environment for power distribution networks, communication and automation/control applications
- Coupling of the IEC 61499/4DIAC-based control approach with a Multi-Agent Control system for reconfigurable power distribution networks

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AIT Austrian Institute of Technology

your ingenious partner

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