System for the Verification of Control Algorithms via HIL-Simulation using PowerFactory

engineering innovative power solutions for a better world.

powercorp

---

powercorp
engineering innovative power solutions for a better world.

Agenda

- **Concept**
- Hardware-in-the-loop Concept
- Developed Hardware-in-the-loop System
- Real Time Simulation Results
- Prospect
- Summary

Concept

"The proof of concept of a hardware-in-the-loop simulation that allows testing of controller functionality within a simulated power system."

Agenda

- Concept
- **Hardware-in-the-loop Concept**
- Developed Hardware-in-the-loop System
- Real Time Simulation Results
- Prospect
- Summary

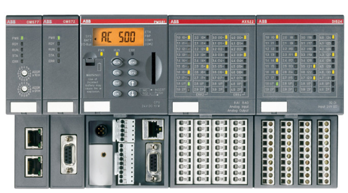
powercorp
engineering innovative power solutions for a better world.

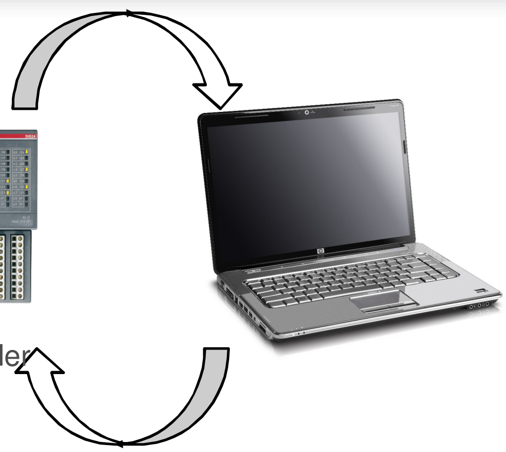
Simulated Power System in PowerFactory

- PowerFactory running on Computer
- Reproducible Specific Event Scenarios
- Repeatable Tests
- Graphs
- Documentation

powercorp
engineering innovative power solutions for a better world.

Hardware-in-the-loop Simulation





- Integration of Controller
- Simulation includes Calculations from Controller

powercorp
engineering innovative power solutions for a better world.

Agenda

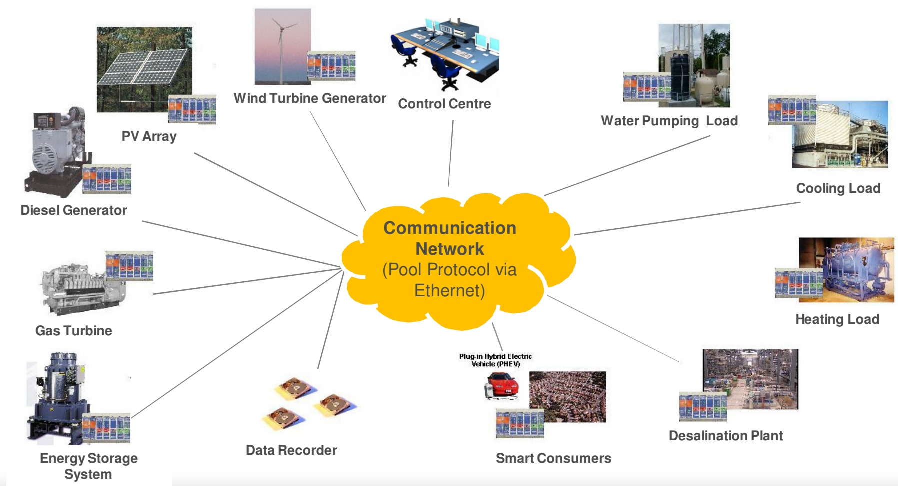
- Concept
- Hardware-in-the-loop Concept
- **Developed Hardware-in-the-loop System**
- Real Time Simulation Results
- Prospect
- Summary

powercorp
engineering innovative power solutions for a better world.

Power System Architecture

engineering innovative power solutions for a better world.

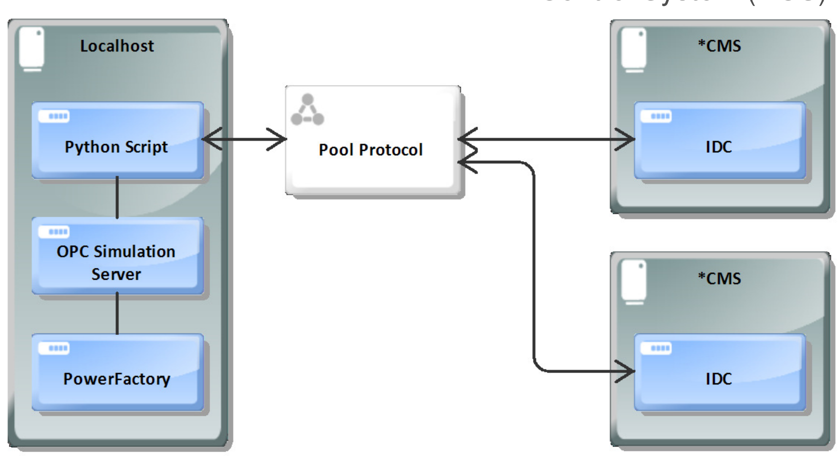
Power System Architecture



engineering innovative power solutions for a better world.

H-I-L System Architecture

Powercorp Distributed Control System (DCS)



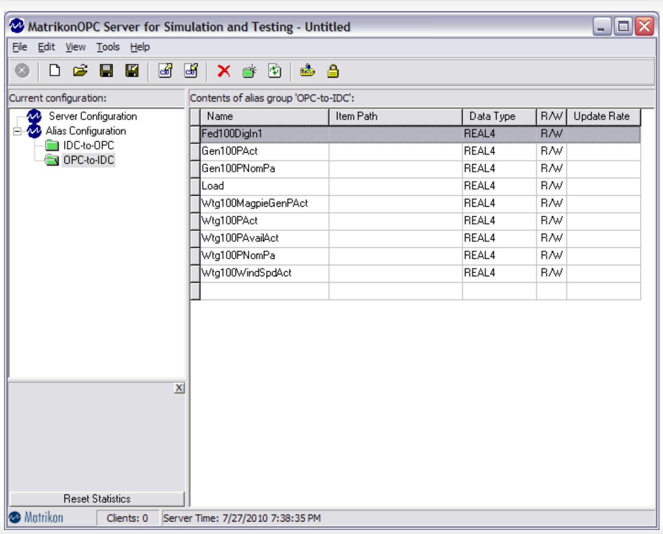
OPC Server

- Free Software & Free Support
- Runs on Windows Machines
- Accessible through the Network
- Names of Variables can be chosen as required.
- They have to match signals within PowerFactory

Typical Data Definition

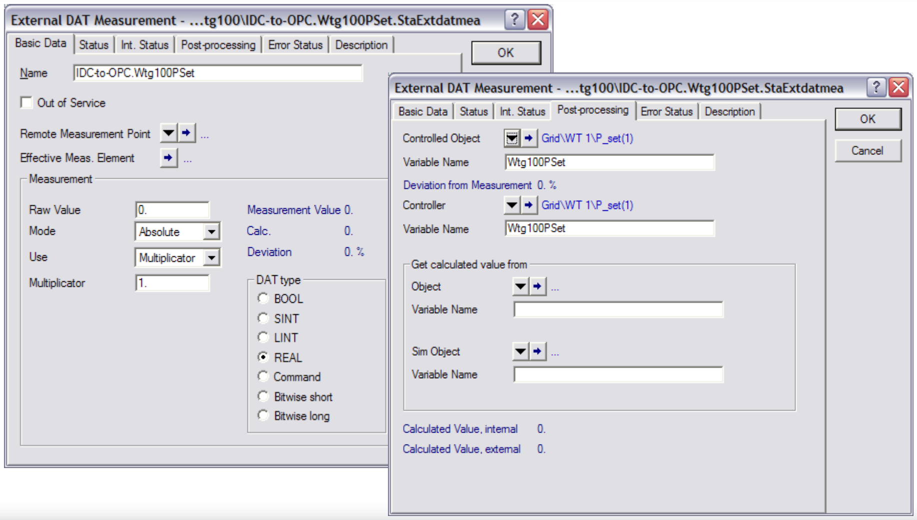
11	# GroupName	AliasName	Item Path	DataType	ReadOnly	PollAlways	UpdateRate	
12	OPC-to-IDC	Wtg100PAct		4	0	0	0	0
13	OPC-to-IDC	Wtg100PAvailAct		4	0	0	0	0
14	OPC-to-IDC	Wtg100WindSpdAct		4	0	0	0	0
15	OPC-to-IDC	Wtg100PNomPa		4	0	0	0	0
16	OPC-to-IDC	Wtg100MagpieGenPAct		4	0	0	0	0
17	OPC-to-IDC	Gen100PNomPa		4	0	0	0	0
18	OPC-to-IDC	Gen100PAct		4	0	0	0	0
19	OPC-to-IDC	Fed100DigIn1		4	0	0	0	0
20	OPC-to-IDC	Load		4	0	0	0	0
21	IDC-to-OPC	Wtg100PSet		4	0	0	0	0
22	IDC-to-OPC	Fed100DigOut0		4	0	0	0	0
23	IDC-to-OPC	Fed100DigOut1		4	0	0	0	0
24	IDC-to-OPC	Rio100DigIn4		4	0	0	0	0
25	IDC-to-OPC	Wtg100MagpieGenPAct		4	0	0	0	0

OPC Server



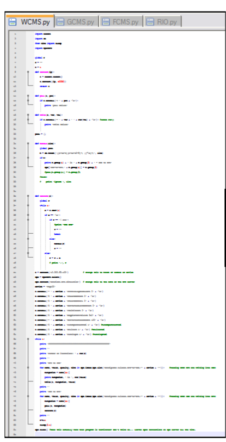
powercorp
engineering innovative power solutions for a better world.

Interaction to OPC Server



powercorp
engineering innovative power solutions for a better world.

Python Script



Python Script

Looking for variables

OPC Server

11	# GroupName	AliasName	Item Path	DataType	ReadOnly	PollAlways	UpdateRate	
12	OPC-to-IDC	Wtg100PAct		4	0	0	0	0
13	OPC-to-IDC	Wtg100PAvailAct		4	0	0	0	0
14	OPC-to-IDC	Wtg100WindSpdAct		4	0	0	0	0
15	OPC-to-IDC	Wtg100PNomPa		4	0	0	0	0
16	OPC-to-IDC	Wtg100MagpieGenPAct		4	0	0	0	0
17	OPC-to-IDC	Gen100PNomPa		4	0	0	0	0
18	OPC-to-IDC	Gen100PAct		4	0	0	0	0
19	OPC-to-IDC	Fed100DigIn1		4	0	0	0	0
20	OPC-to-IDC	Load		4	0	0	0	0
21	IDC-to-OPC	Wtg100PSet		4	0	0	0	0
22	IDC-to-OPC	Fed100DigOut0		4	0	0	0	0
23	IDC-to-OPC	Fed100DigOut1		4	0	0	0	0
24	IDC-to-OPC	Rio100DigIn4		4	0	0	0	0
25	IDC-to-OPC	Wtg100MagpieGenPAct		4	0	0	0	0

powercorp
engineering innovative power solutions for a better world.

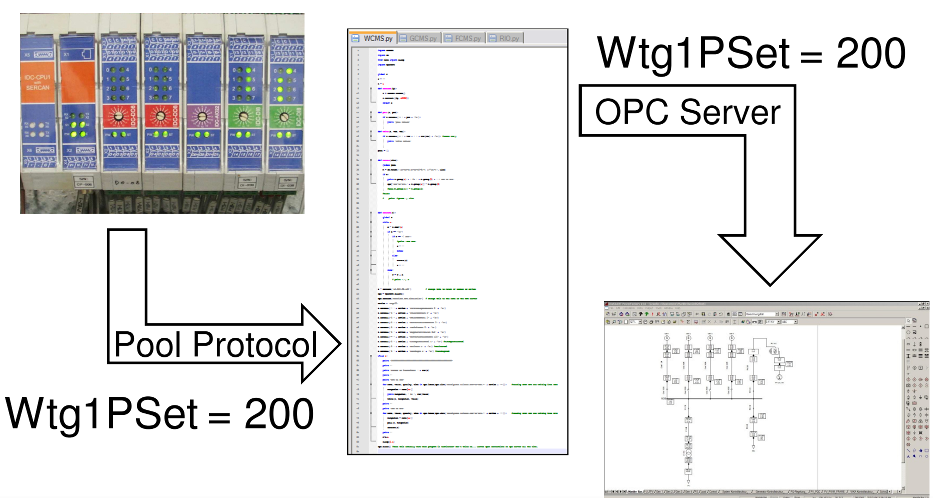
Python Script

```
While(1)
  {
  for(items in OPC-to-IDC)
        read-var-val(OPC-to-IDC)      // From the OPC Server
        write(variables, values)      // = Wtg1PAct 300

  for(items in IDC-to-OPC)
        read-var(IDC-to-OPC)          // From the OPC Server
        poll-for-val(variable)        // ? Wtg1PSet
        write(variable, value)        //  Write into OPC Server
  }
```

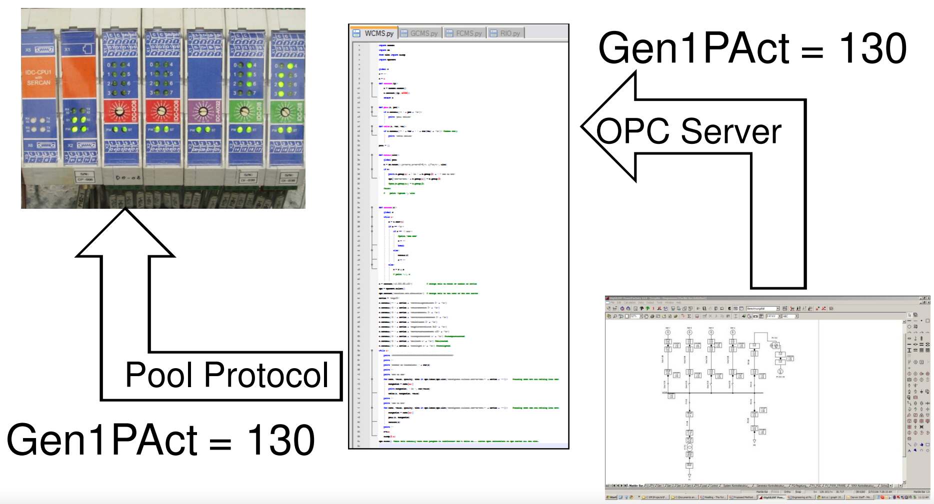

powercorp
engineering innovative power solutions for a better world.

Group IDC-to-OPC



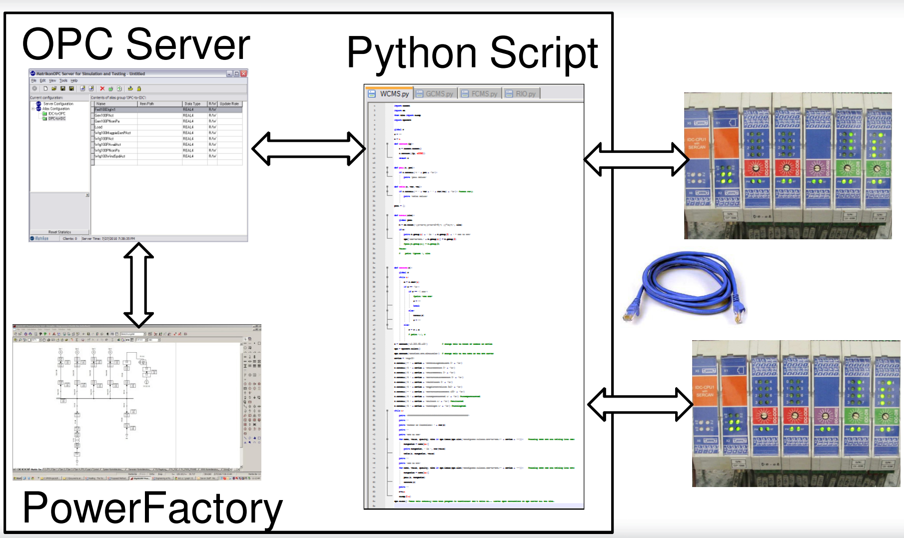
powercorp
engineering innovative power solutions for a better world.

Group OPC-to-IDC



powercorp
engineering innovative power solutions for a better world.

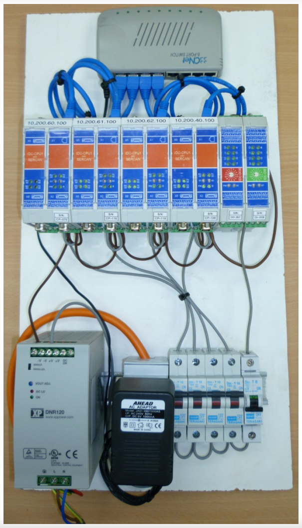
H-I-L System Architecture



powercorp

engineering innovative power solutions for a better world.

The actual test board



- Network Switch
- GCMS
- WCMS
- FCMS
- RIO (CB status, CB close for load step)
- Circuit Breaker
- Power Supply

powercorp

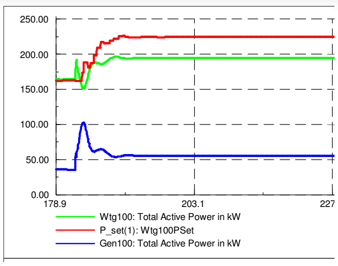
engineering innovative power solutions for a better world.

Agenda

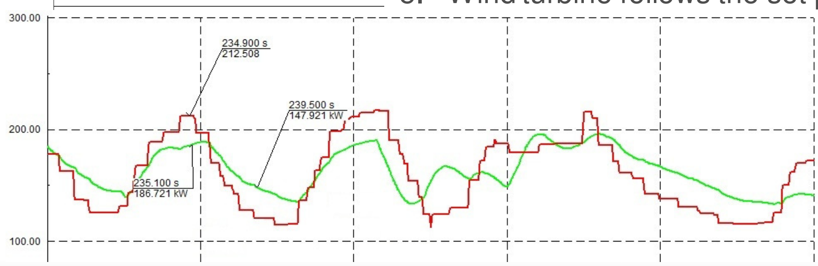
- Concept
- Hardware-in-the-loop Concept
- Developed Hardware-in-the-loop System
- **Real Time Simulation Results**
- Prospect
- Summary

powercorp
engineering innovative power solutions for a better world.

Successful Interaction

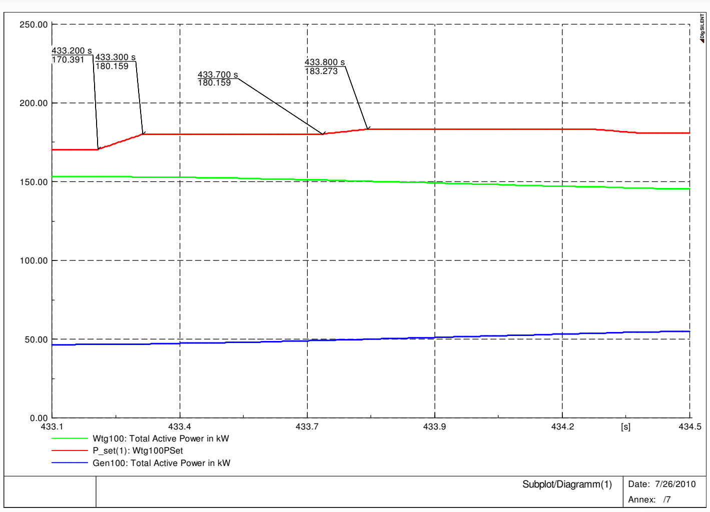


1. Wind speed is constant
2. Controller turned off - on
3. Wind speed is measured by controller
4. Set Point (red) increases after turning on controller
5. Wind turbine follows the set point



powercorp
engineering innovative power solutions for a better world.

Communication Speed



Time difference between each transmitted change in set point: 100ms

powercorp
engineering innovative power solutions for a better world.

Agenda

- Thesis Statement
- Hardware-in-the-loop Concept
- Developed Hardware-in-the-loop System
- Real Time Simulation Results
- **Prospect**
- Summary

powercorp
engineering innovative power solutions for a better world.

Use and Benefits

- Use as Development Tool for new Control Algorithms
  - New Control Algorithms can be tested against a Real Power System
- Show System for Customers
  - Education of Customers
  - Demonstration of the DCS Functionality and its Value
- Hardware Testing Platform
  - Use as tool to test new Hardware before Commitment to a complete system

powercorp
engineering innovative power solutions for a better world.

New Controller Development

- How we do controller development now:
  - *Writing* of the distributed control Requirements Specification
  - *Adding* relevant Use Case Scenarios
  - *Propose* control algorithms
  - *Analyse* the algorithms (first analysis of performance)
  - *Implement* the control algorithms within PowerFactory
  - *Measure* their performance by simulating operation within PowerFactory (second analysis of performance)
  - *Implement* the final algorithms on the controller hardware
  - *Run* the power system model with H-I-L operation of the controller hardware in PowerFactory in real-time
  - *Test* against the Use Case Scenarios (third analysis of performance)

powercorp
engineering innovative power solutions for a better world.

Agenda

- Concept
- Hardware-in-the-loop Concept
- Developed Hardware-in-the-loop System
- Real Time Simulation Results
- Prospect
- **Summary**

engineering innovative power solutions for a better world.

Summary

- Proof of Concept – It's Working!

but

- Improvements can be made – It's a Proof of Concept!

engineering innovative power solutions for a better world.

engineering innovative power solutions for a better world.

Head Office
Darwin Business Park
Export Drive
Berrimah 0828, N.T.
Australia
mail@pcorp.com.au
+61889470933
www.pcorp.com.au

Europe Office
Wissenschaftspark Trier
Am Wissenschaftspark 29
54296 Trier
Germany
mail@powercorp.eu
+4917683234822
www.powercorp.eu