INTRODUCTION to PHIL
Power Hardware-In-the-Loop

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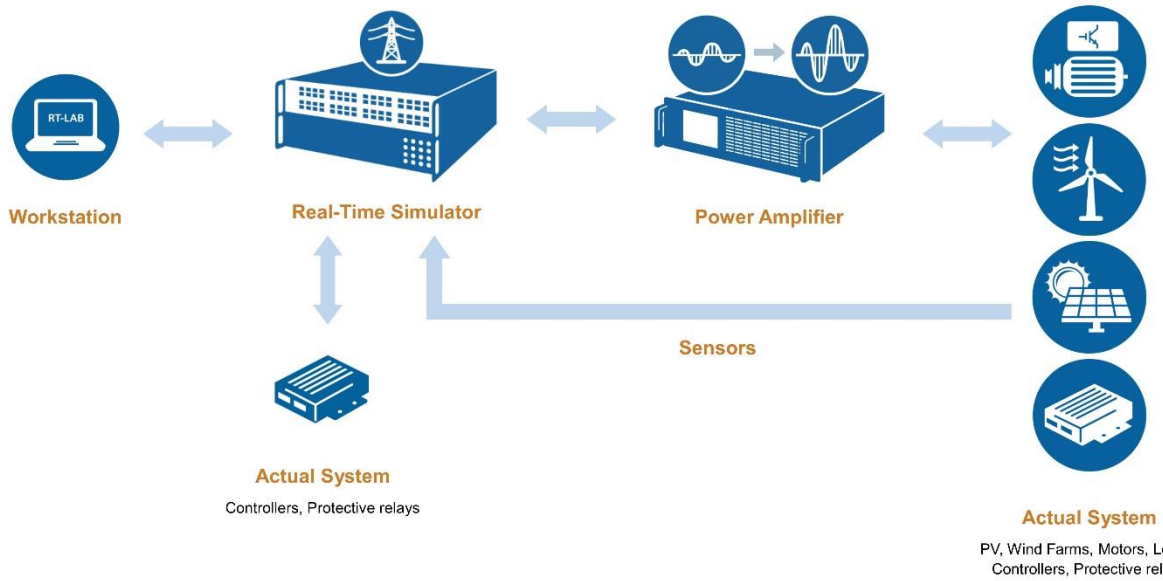
Power Hardware-In-the-Loop

PHIL simulation is a scenario where a simulation environment virtually exchanges power with real hardware, in contrast to the usual case in hardware-in-the-loop simulation, which involves only signal exchange.



Benefits, features and accomplishments

- Join the real-time simulator capabilities to the power equipment
  - Power systems, power electronic, protection equipement, controller logic, etc.
- Requires high quality amplifier
  - High accuracy, low distorsion, high bandwith, low phase lag, etc.
- Connect a real power device under test
  - Wind turbine, solar panel, motors/generators, protection relays, etc.

Potential Applications

- **Grid Applications**
  - Grid Emulator (50, 60, 400 Hz)
  - Grid Load
  - PV-Inverter Emulation
  - Wind-Generator Emulation
  - UPS (Uninteruptible Power Supply) Emulation
  - Grid Inverter Emulation
  - Grid Motor / Generator Emulation
- **Motor Applications**
  - Motor / Generator Emulator
  - Drive Inverter Emulator
  - Frequency Inverter Emulator
- **Aerospace / Military**
  - 400 Hz Supply Grid Emulator
  - DC-Supply emulation
  - 400 Hz Aerospace device emulator
  - AC-DC Coupling Emulator
  - Generator / Motor Emulator
  - 400 Hz Inverter Emulator
- **Automotive Applications**
  - **Electrical drive train emulation**
    - Battery Emulator
    - Drive Inverter Emulator
    - Motor Emulator
  - **eVehicle Applications**
    - eVehicle charging station emulator
    - Test Bench for charging
  - **Test Benches for combustion engine drive train**
    - Drive Inverter for electrical machines connected to combustion machines, wheel, gear boxes
- **Transportation**
  - Supply Grid Emulator
  - Machine Emulator
  - Inverter Emulator
  - Electrical drive train emulation

Courtesy of EGSTON

OPAL-RT Solutions

- OP5600
  - IO and EtherCAT
- OP4500
  - IO, EtherCAT and ORION
- OP5607
  - IO, FPGA motor modeling and cascading of units
- OP7000
  - IO, Multi-FPGA ans FPGA motor modeling

Partnerships

Proud Sponsors of RT14

triphase

EGSTON

Other PHIL partners

PUISSANCE+

AMETEK

Today's presenters

- Triphase
  - Amplifiers with the EtherCAT daisy-chain network solution for PHIL

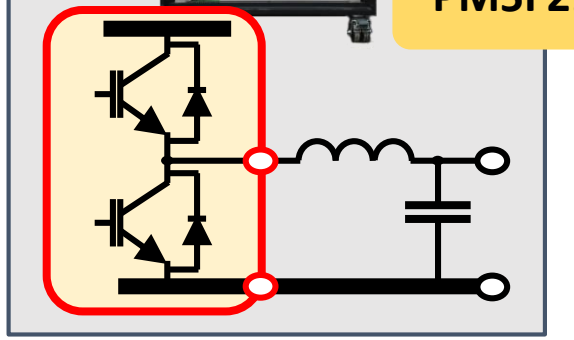
- EGSTON
  - COMPISO amplifier with the ORION optic fiber communication solution for PHIL

triphase

OP5600

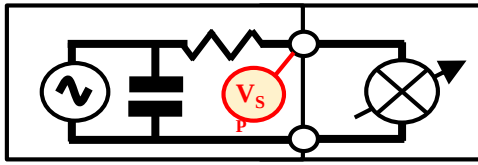
DPM75

PM5F21



SIMULATOR

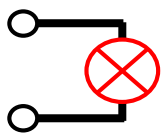
Reference Simulation



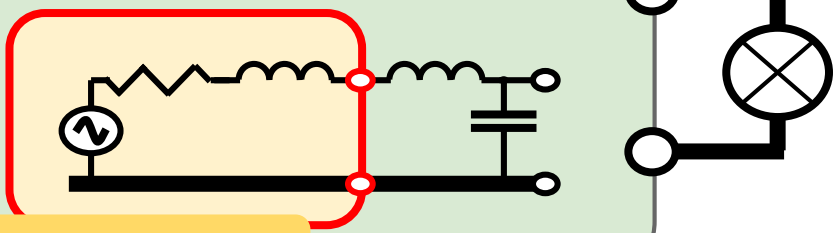
Predistortion

$$\frac{V_{SP}+Z_S(s)I}{H_a(s)}$$

Observer

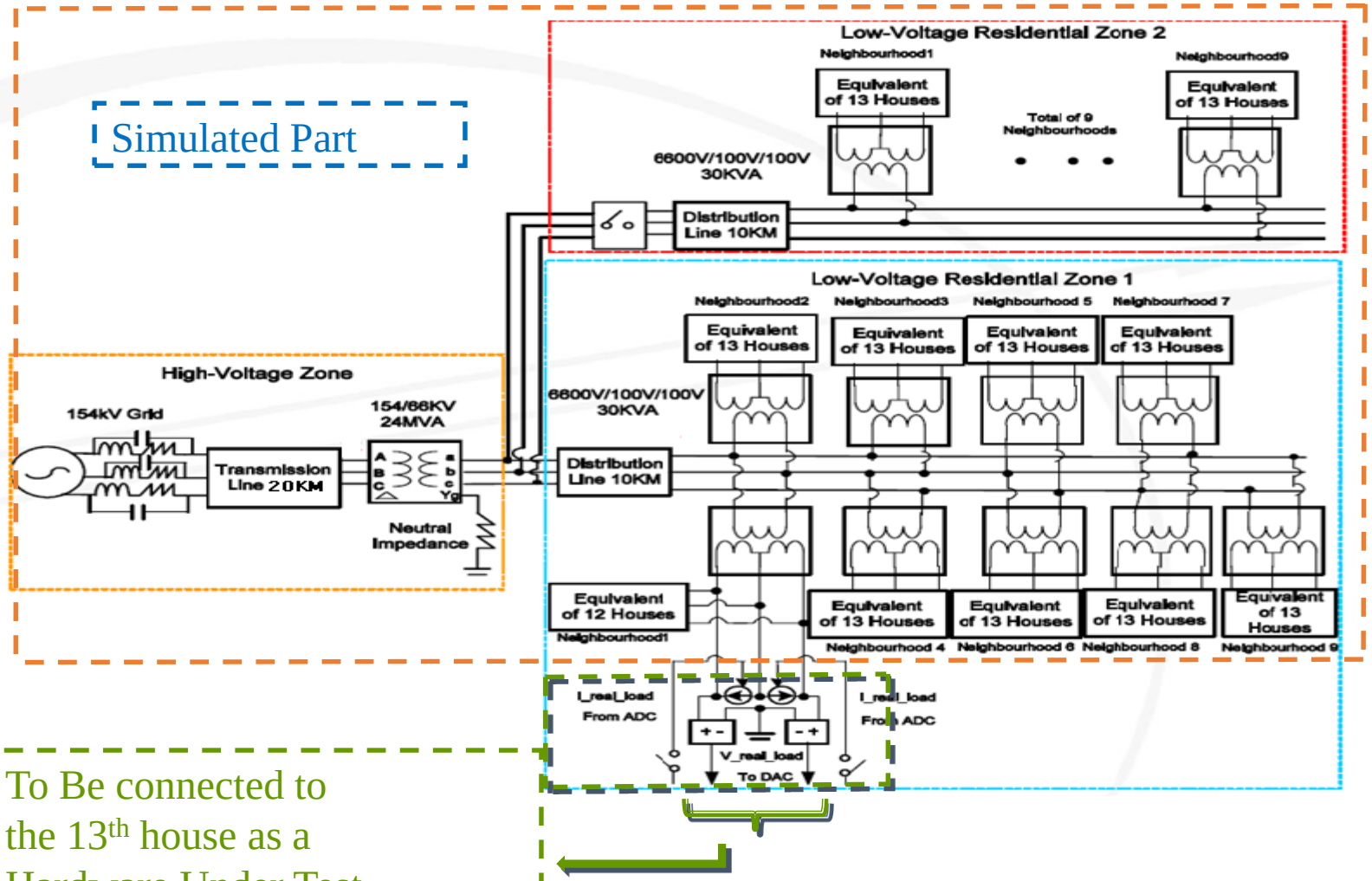


POWER MODULE



Triphase Emulated Circuit Technology

EGSTON


Simulated Part
Low-Voltage Residential Zone 2
Neighbourhood1
Equivalent of 13 Houses
Total of 9 Neighbourhoods
Neighbourhood9
Equivalent of 13 Houses
6600V/100V/100V 30KVA
Distribution Line 10KM
Low-Voltage Residential Zone 1
Neighbourhood2
Neighbourhood3
Neighbourhood 5
Neighbourhood 7
Equivalent of 13 Houses
6600V/100V/100V 30KVA
Distribution Line 10KM
High-Voltage Zone
154kV Grid
154/66KV 24MVA
Transmission Line 20KM
Neutral Impedance
Equivalent of 12 Houses
Neighbourhood1
Neighbourhood 4
Neighbourhood 6
Neighbourhood 8
Neighbourhood 9
I_real_load From ADC
V_real_load To DAC
To Be connected to the 13th house as a Hardware Under Test