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Validating a Wide Area Grid Frequency Control System using P-HiL

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SP ENERGY NETWORKS
Scottish and Southern Electricity Power Distribution
UK Power Networks
vodafone
S&C
Locamation smart smart grid solutions
OMICRON
Scottish Funding Council Promoting further and higher education
Scottish Enterprise

Agenda

Project background

PNDC overview

Control solution overview

Testing methodology

PNDC implementation

P-HiL Strategy

Summary

Smart Frequency Control Project

- £9m NIC project led by National Grid
- **Fast regional** frequency response
- Underpinned by WAMPAC and flexibility resources

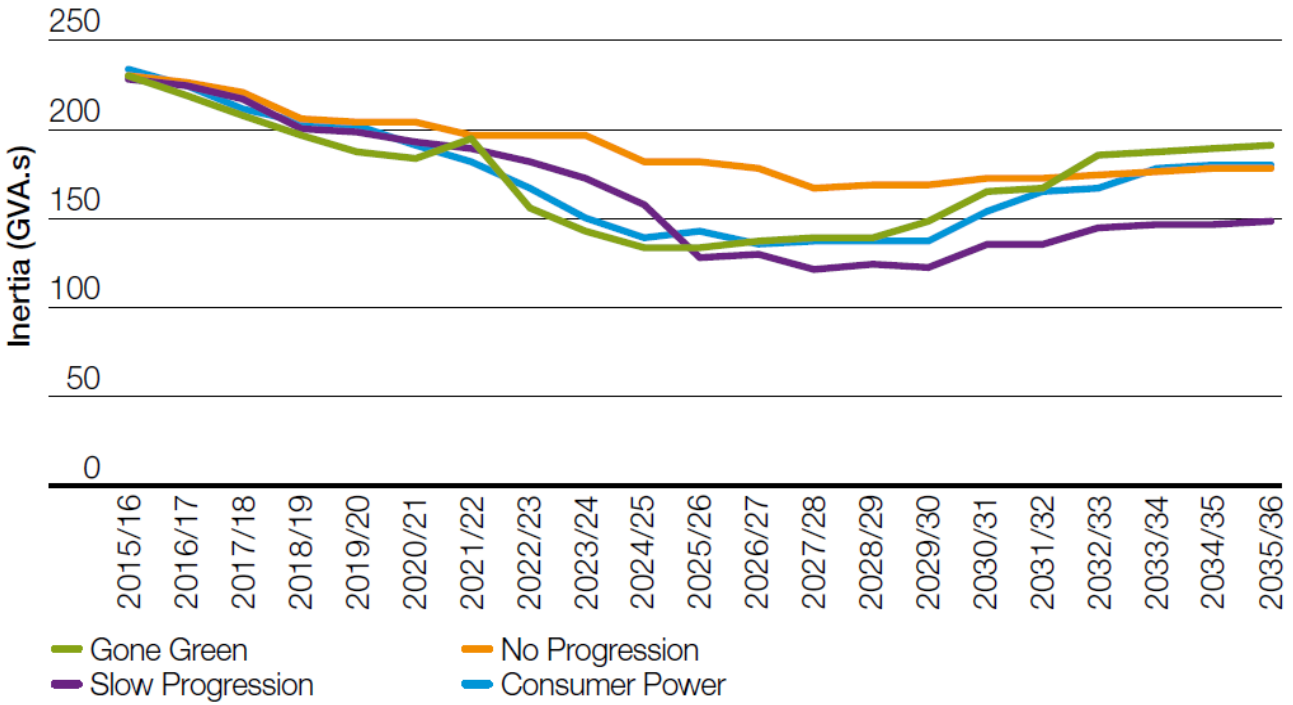
nationalgrid

centrica

BELECTRIC™ Flexitricity

University of Strathclyde Glasgow

MANCHESTER 1824
The University of Manchester



Minimum system inertia including embedded generation - National Grid System Operability Framework 2015

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PNDC Overview

HV Network (11kV)

Three underground feeders for a total equivalent length of 6km.

One overhead feeder for a total equivalent length of 60km

Apply resistive line and earth faults.

11kV/400V transformers from 500kVA to 16kVA

Pole mounted auto reclosers

Series voltage regulator

LV Network

LV Fed from HV Network

Transformers 16 to 315 kVA

Mock impedances ~ 0.6 km

Load banks ~ 600 kVA (total)

Real Time Simulation

Hardware in the Loop Simulation

3-50µs simulation time-step … up to 9000 nodes in distribution mode.

Accurate frequency response up 3kHz

Industry Standard DMS/ SCADA

PowerOn Fusion monitoring control and switching management

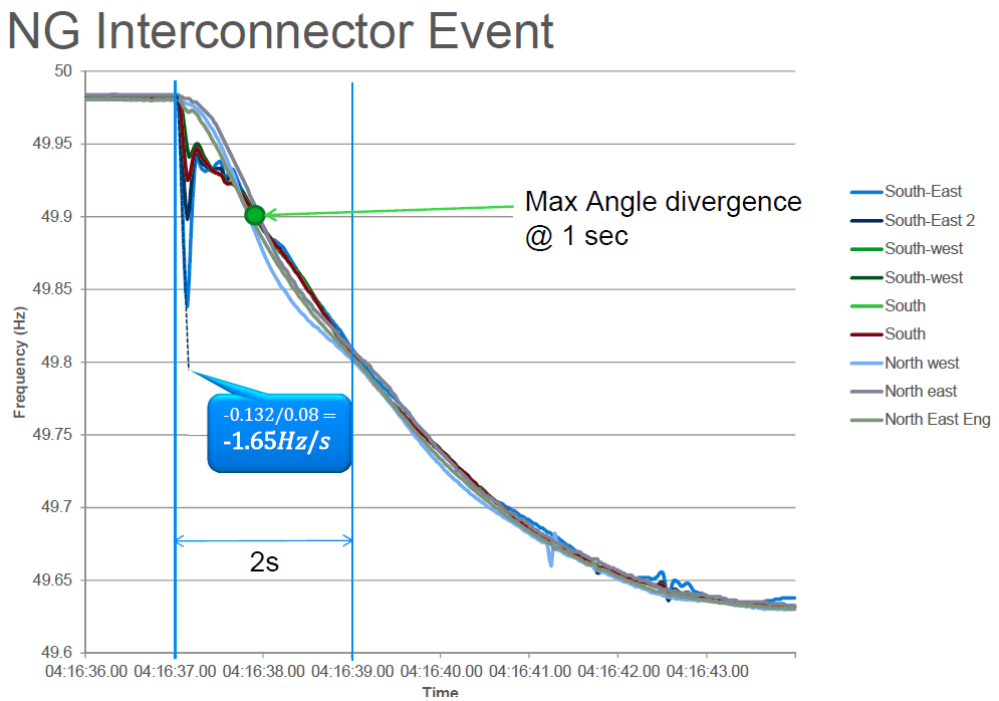
Power Supply

On Grid : 11kV Connection to Primary Substation

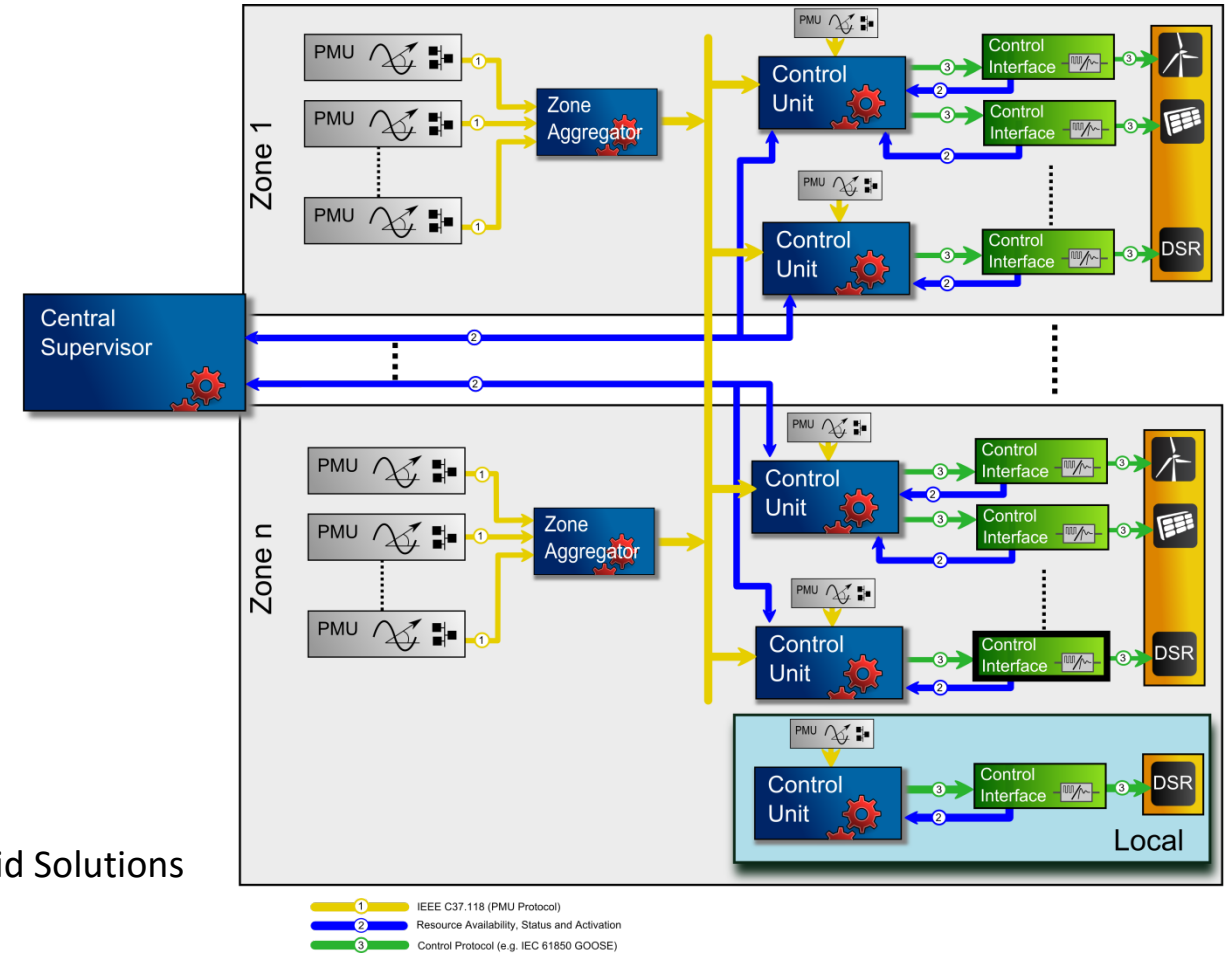
Off Grid : 5MVA Generator

11/11kV Isolation Transformer

Control Solution Overview

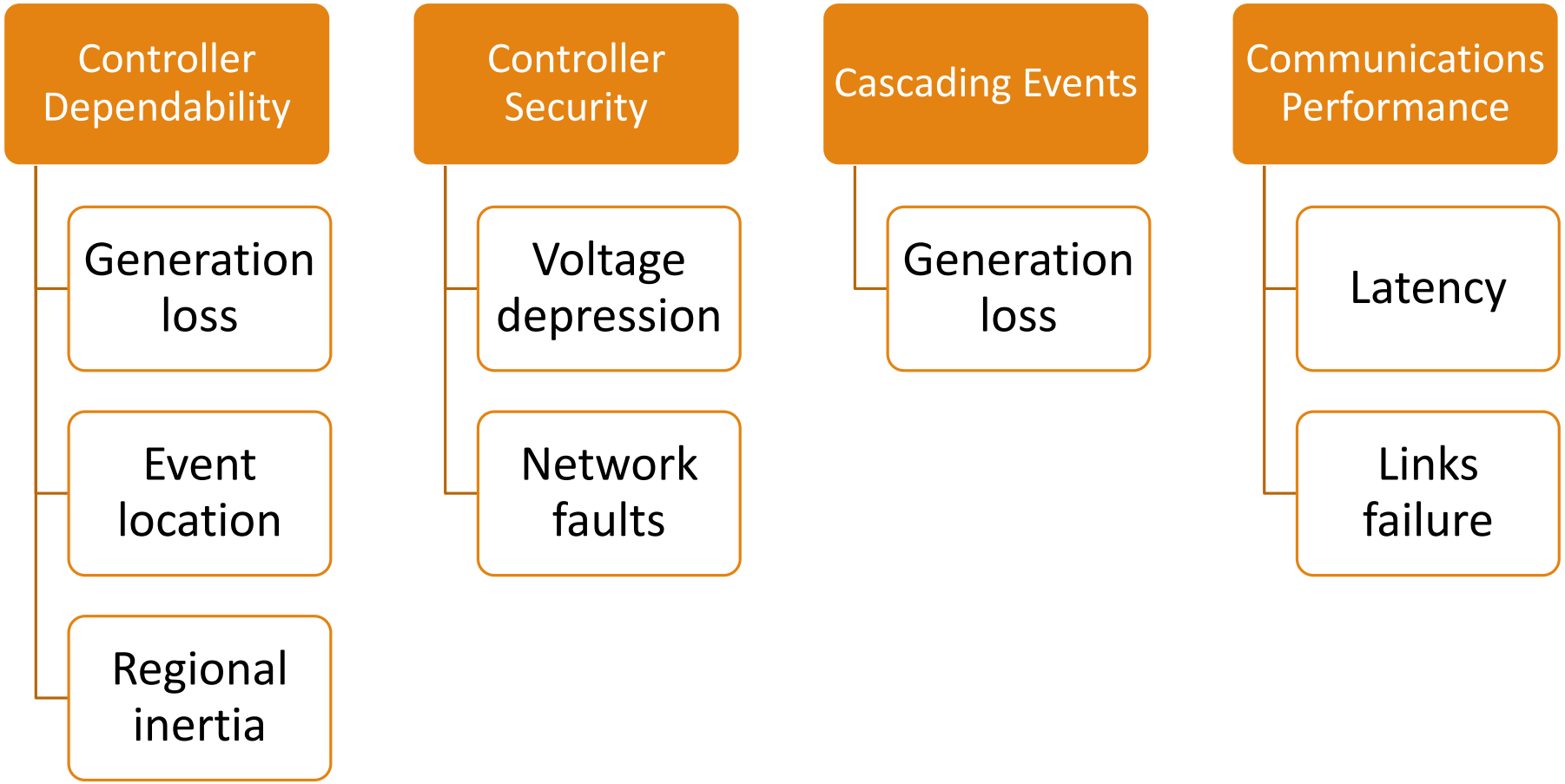


Figures courtesy of GE Grid Solutions

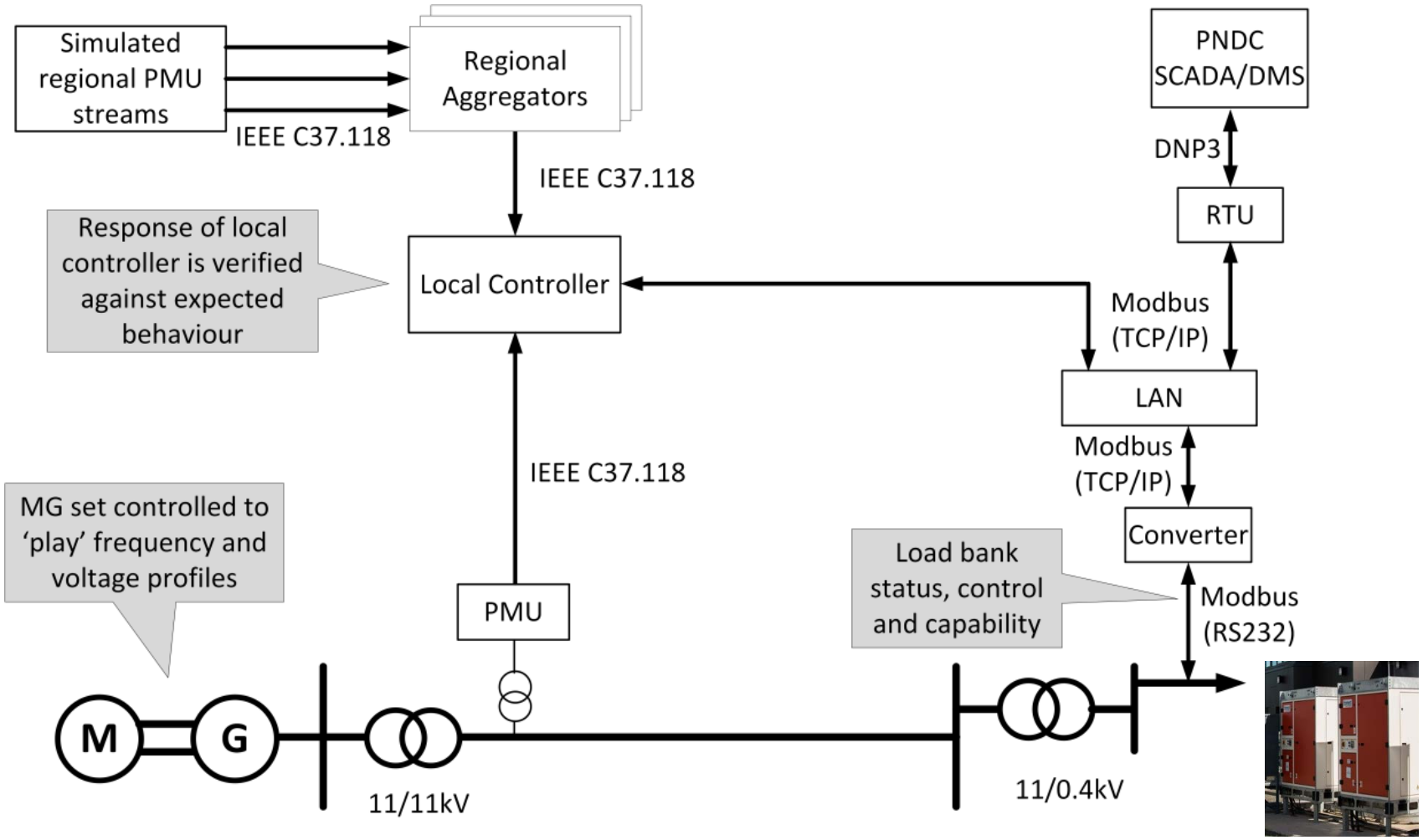


Testing Methodology

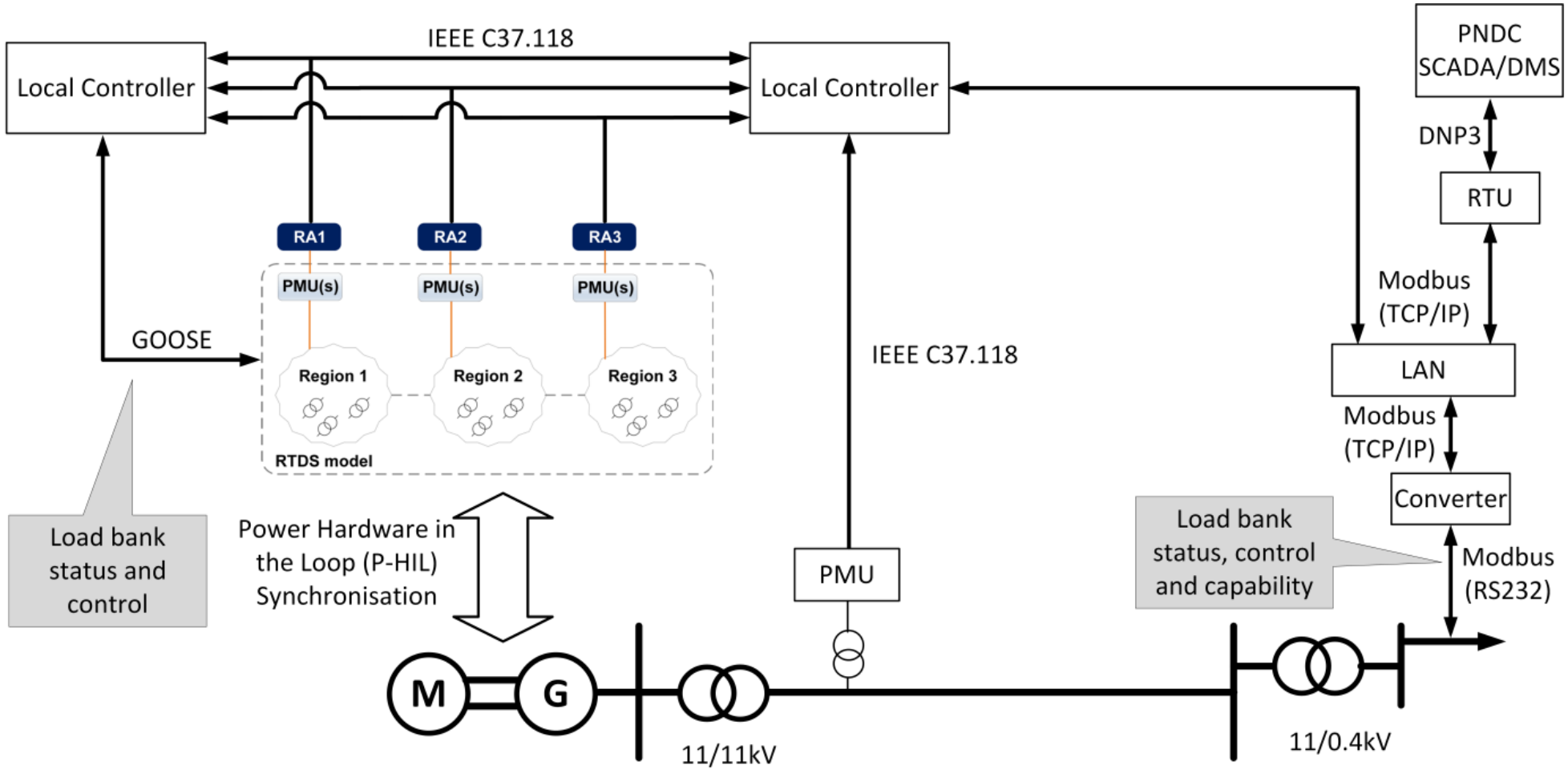
- System testing



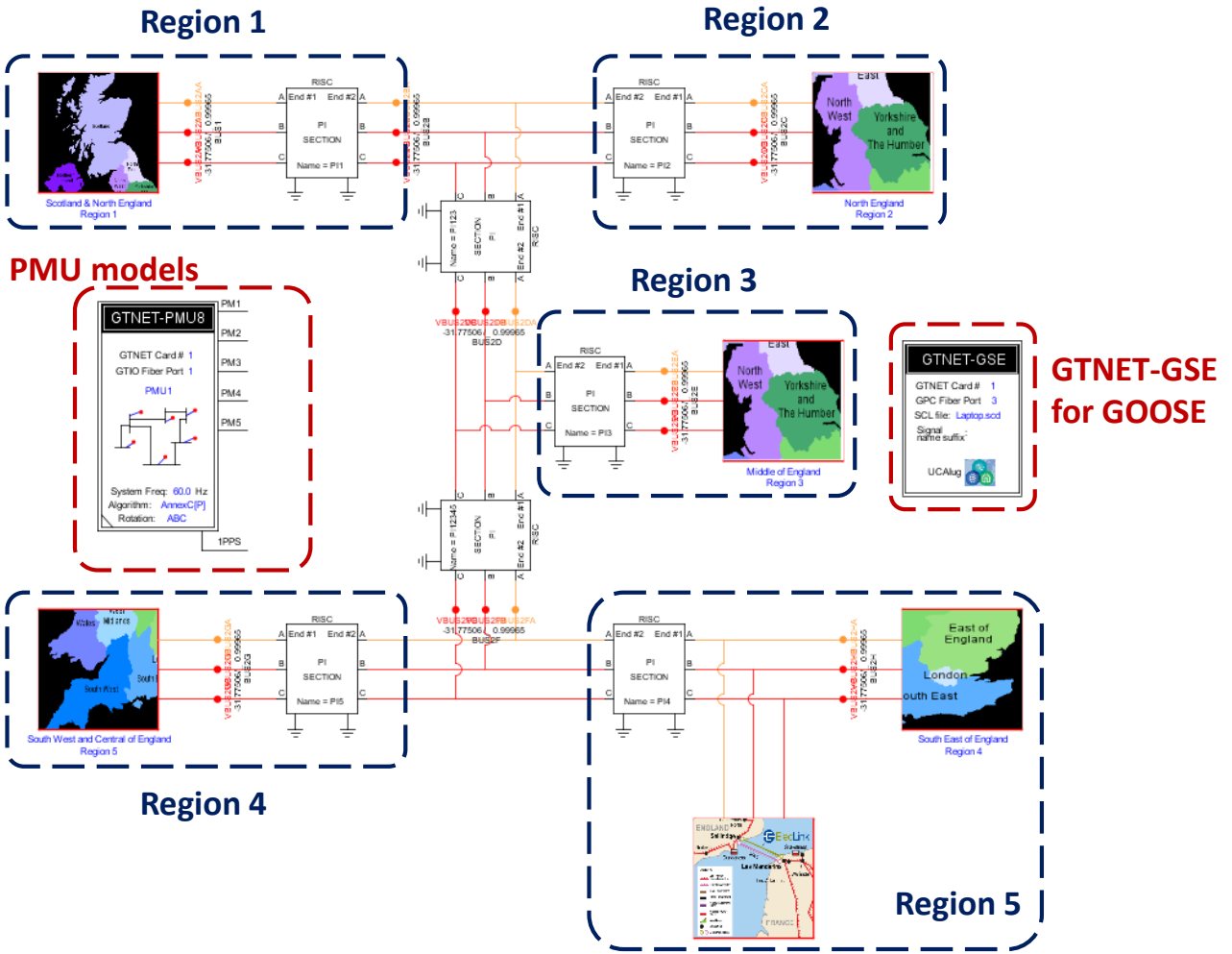
Open Loop Testing



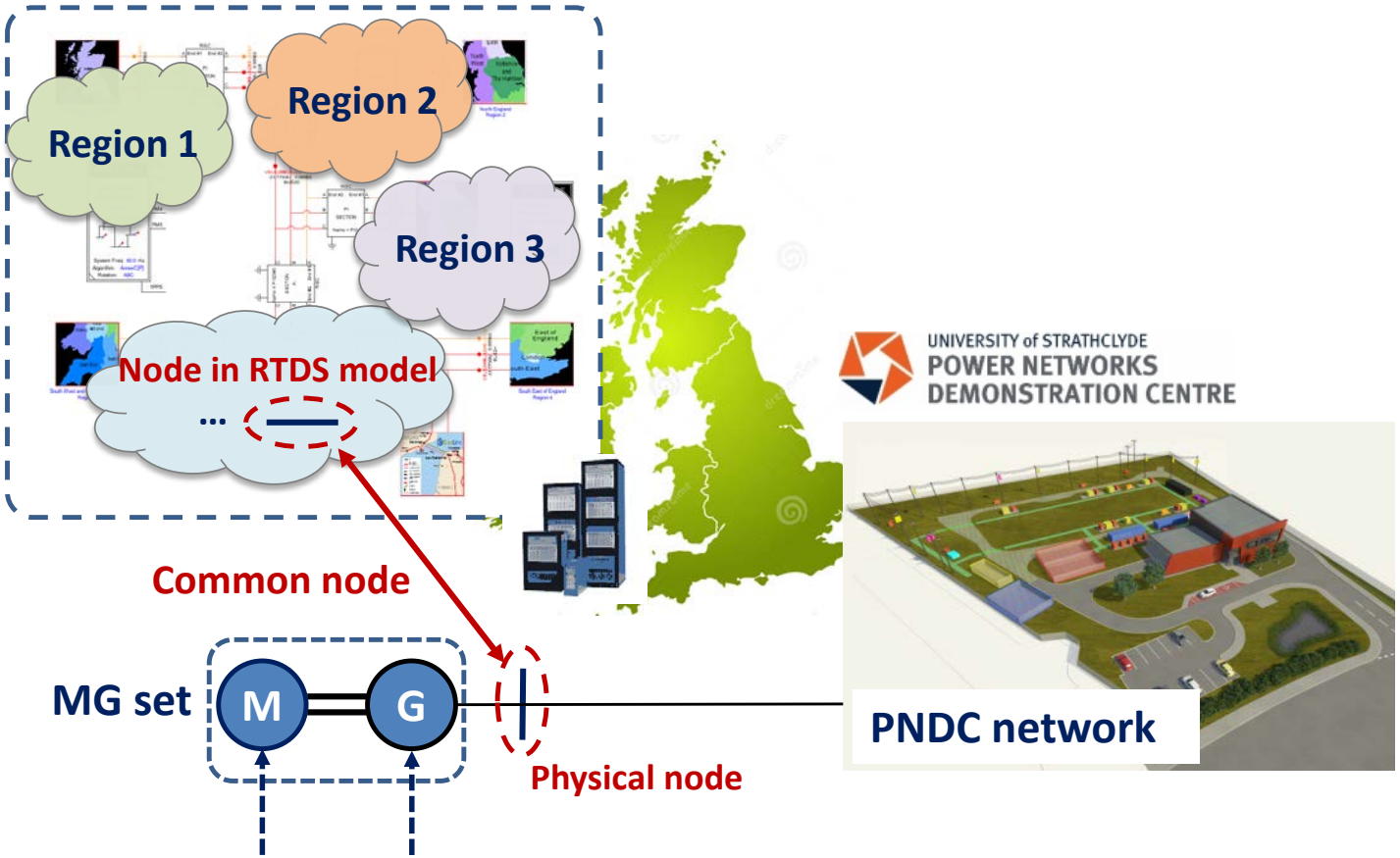
Closed Loop Testing



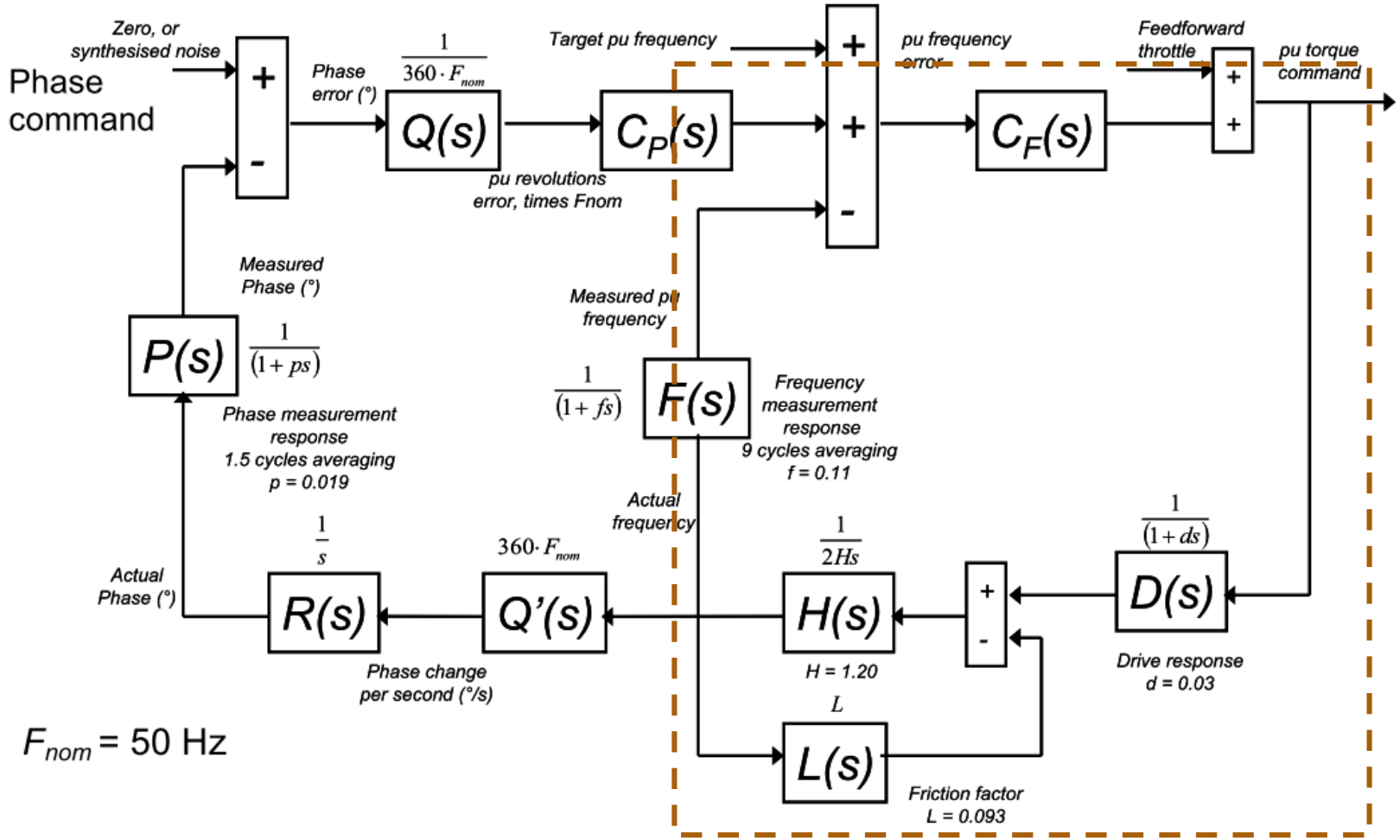
Five Region RTDS Model



P-HiL Strategy



P-HiL Controls

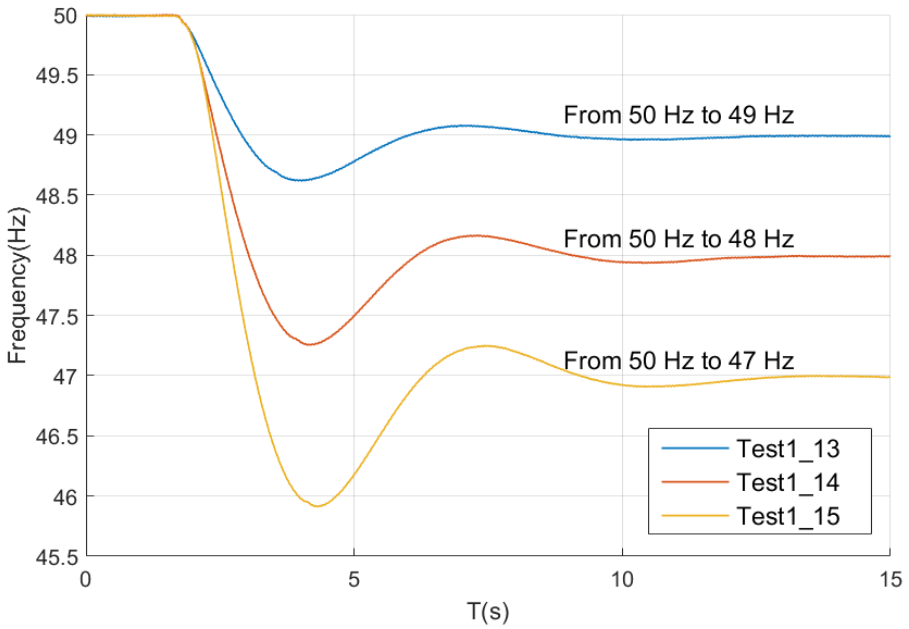


Roscoe, A. J. and Elders, I. M. and Hill, J.E. and Burt, G. M. "*Integration of a mean-torque diesel engine model into a hardware-in-the-loop shipboard network simulation using lambda tuning*", IET Electrical Systems in Transportation, 1 (3). pp. 103-110

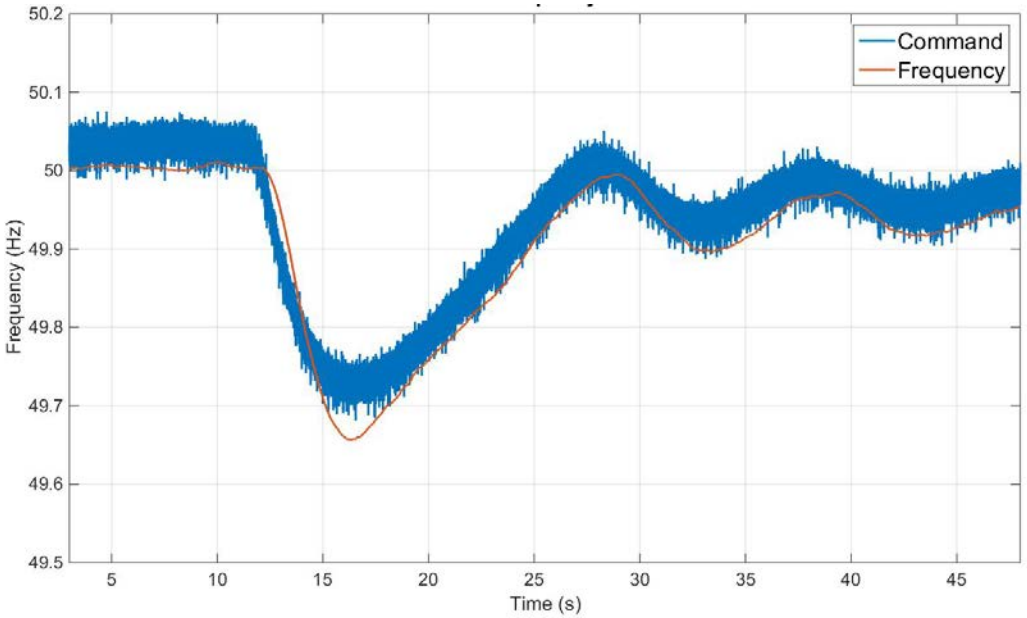
Characterisation of the M-G Set Response

- Create disturbance
- Measure M-G set voltage
- Offline M-G set model validation
- Tune model controls
- Online validation of controls in RTDS

Frequency step



Simulated historic Event



What's Next?

- Installation & commissioning of SFC solution
- Configuration of SFC control scheme
- Implementation of M-G set interface
- SAT
- Testing

Summary

- Challenges caused by reduced and varied system inertia.
- Requirements for a targeted frequency response.
- Importance of rigorous de-risking of new control solutions.
- Realistic testing approaches enabled through real-time simulation.

http://www.nationalgridconnecting.com/The_balance_of_power/index.html