POWER NETWORKS DEMONSTRATION CENTRE

Presentation Overview

1. Introduction to PNDC

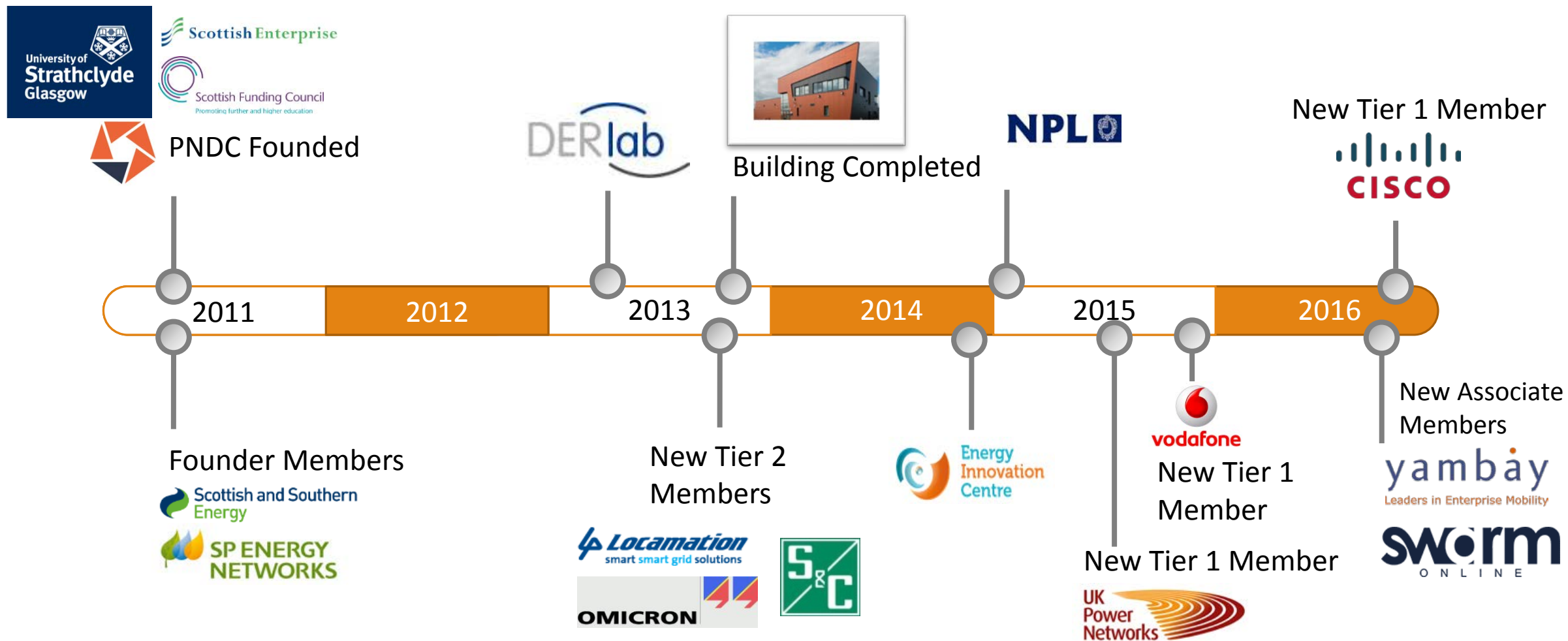2. MGSet Platform Project

3. Q&A

Overview

Background

- Dedicated Power Systems R&D Facility
- Opened in 2014
- Dedicated expert team

- Part of the University of Strathclyde
- Operated in partnership with members
- Multiple vectors of collaboration
- Open access for engagement with Industry for projects

Timeline

PNDC Founded

Building Completed

New Tier 1 Member

2011 | 2012 | 2013 | 2014 | 2015 | 2016

Founder Members

New Tier 2 Members

New Tier 1 Member

New Associate Members

New Tier 1 Member

New Tier 1 Member

PNDC In Numbers

9 — Industrial Members

84 — PNDC projects to date

6 — Active research themes with published roadmaps

81,015 — Impressions through social media marketing
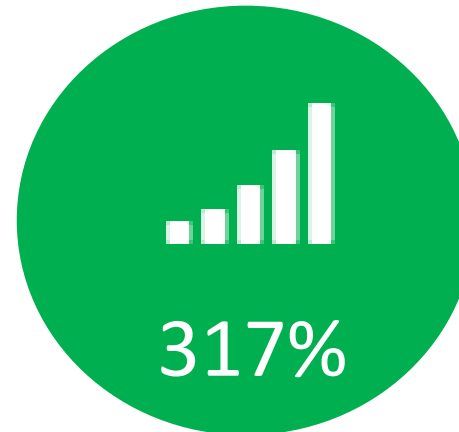
317% — 4 Yr Annual Growth Rate *2012/13 – 2015/16*

25 — PNDC staff
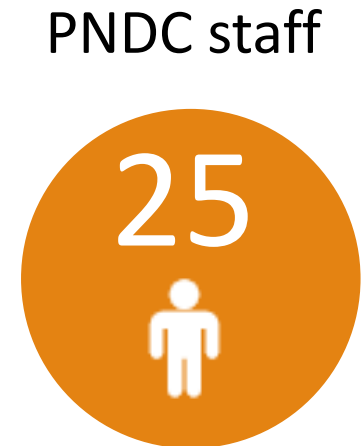
PNDC – Unique Testing Capabilities

Power Supplies

- On Grid : 11kV 2 x 1MVA connections
- 11/11kV 1MVA Isolation Transformer
- TriPhase Convertor: 500KVA ±0-1300V DC
- Off Grid : 1MVA Gen Set

HV Network (11kV)

- 3 x underground feeders for a total equivalent length of 6km.
- 1 x overhead feeder for a total equivalent length of 60km
- 11kV/400V transformers from 1.2 MVA to 25kVA
- Pole mounted auto reclosers
- Series voltage regulator

Power Hardware In the Loop

- Hardware in the Loop Simulation with 6 x racks of RTDS hardware
- Optical interface provides 2 way interaction with both Gen Set and TriPhase Convertors.
- 3-50µs simulation time-step ... up to 360 x 3 phase busses
- Accurate frequency response up 3kHz

LV Network

- LV Fed from HV Network
- Mock impedances ~ 0.6 km
- Load banks total ~ 600 kVA
- Indoor and outdoor test connection points

Industry Standard DMS / SCADA / Historian

- PowerOn Fusion monitoring control and switching management
- OSISoft PI Historian connected to SCADA and Fast Data Acquisition System

Fault Throwing

- High Voltage Fault Throwing Phase to Phase, Phase to Ground, Multiple Injection Points
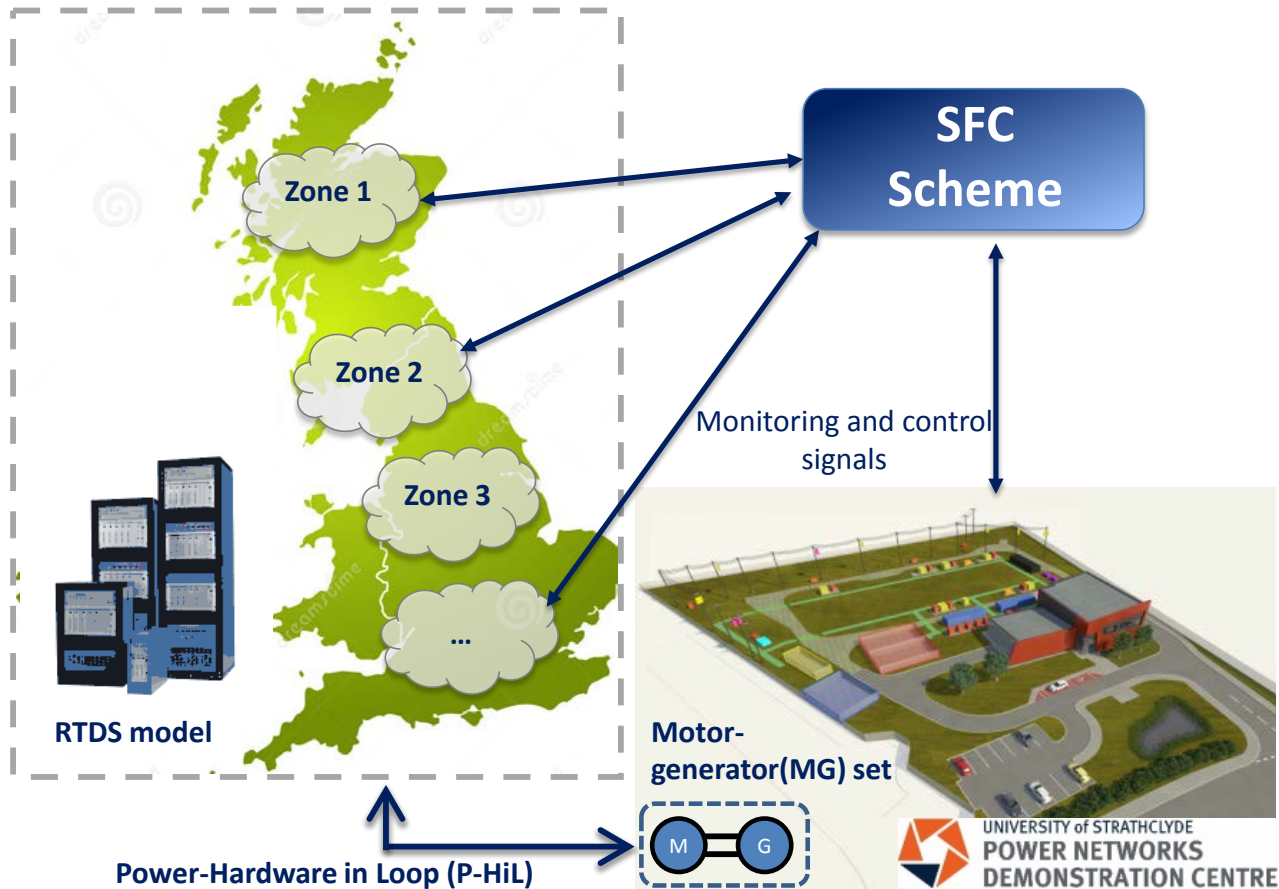- Low Voltage Fault Throwing Unit, Flexible Connection

GRID SIMULATOR TESTING: MGSET PLATFORM

Smart Frequency Control System Testing

Zone 1

Zone 2

Zone 3

...

SFC Scheme

Monitoring and control signals

RTDS model

Motor-generator(MG) set

M — G

Power-Hardware in Loop (P-HiL)

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- Solution for providing frequency response from distributed network resources - £9.3M National Grid led NIC project.

- Manages low and variable system inertia and mitigates risk of system splitting due to inappropriate response.

- PNDC end-to-end validation of vendor solution using power hardware in the loop testing facility.

- UK wide TSO, vendor, academic and service provider collaboration.

GE Control Solution Overview
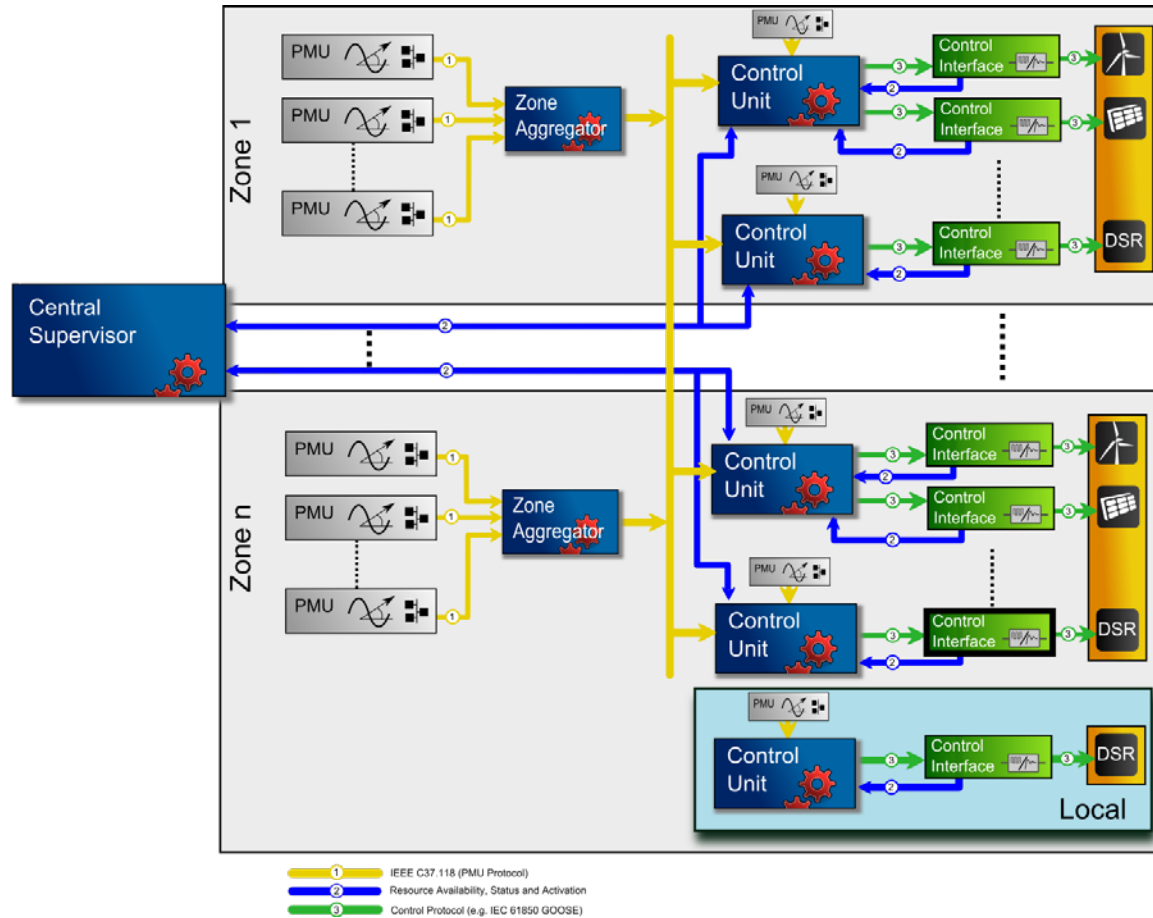
- Wide Area Measurement and Control System (WAMCS).

- Local controllers are used to dispatch resources (e.g. generation, energy storage, demand) in response to a frequency event.

- PMU measurements are used to ensure a coordinated response in line with regional RoCoF variations.

- Central supervisor functionality to optimise the dispatch based on resource availability and characteristics.

P-HiL Setup Overview
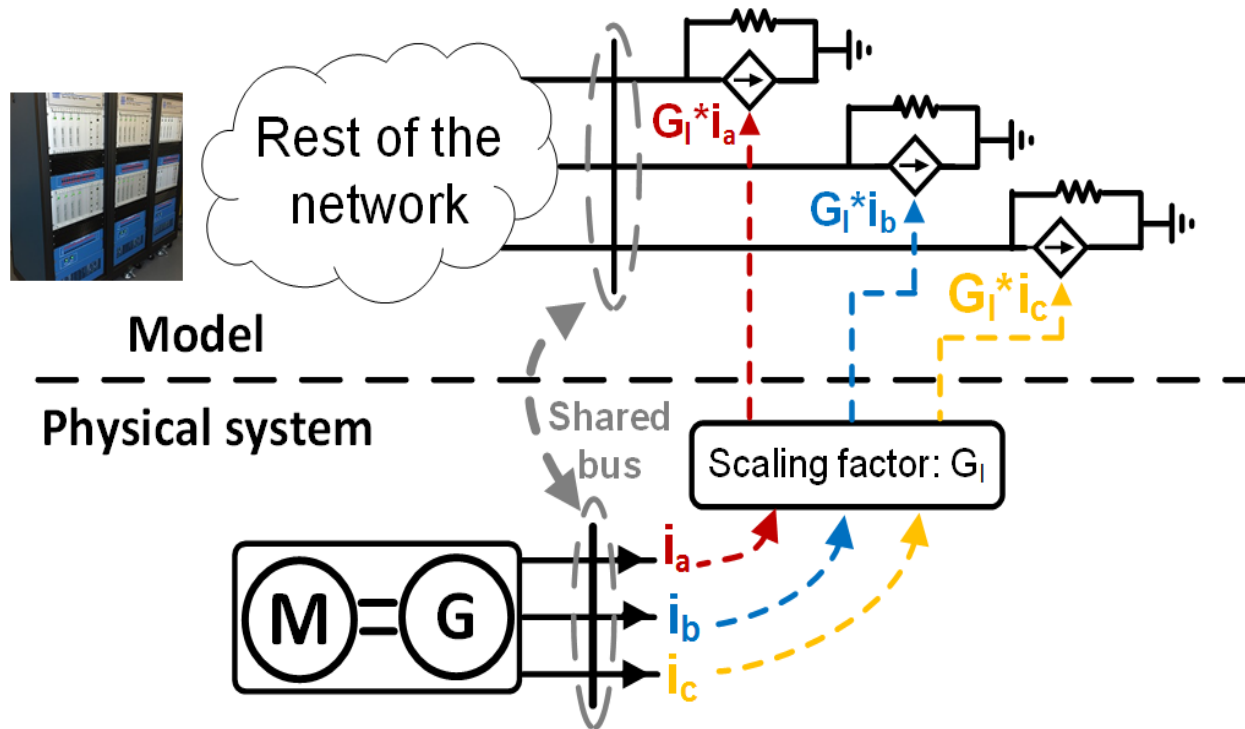
- A reduced UK Grid model implemented in RTDS.

- The PNDC network is connected to one of the simulated busses through a 1MW MG set.

- Challenge of synchronising the MG set bus voltage phasor with that of the simulation using the MG set proprietary controller.

RTDS Model Implementation

- The reduced model is composed of 5 regions.

- Offline studies are used to determine settings for controllers under test.

RTDS Model Validation

Frequency Profile - Loss of Interconnector

Jan 2016 event
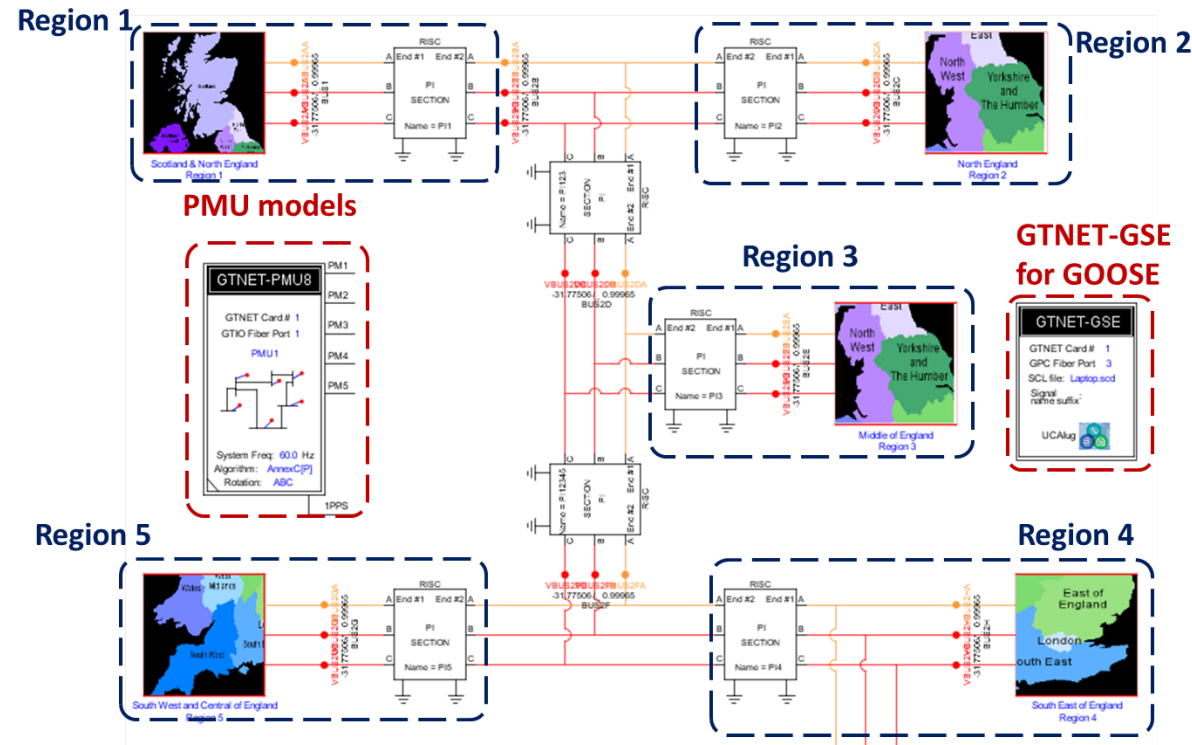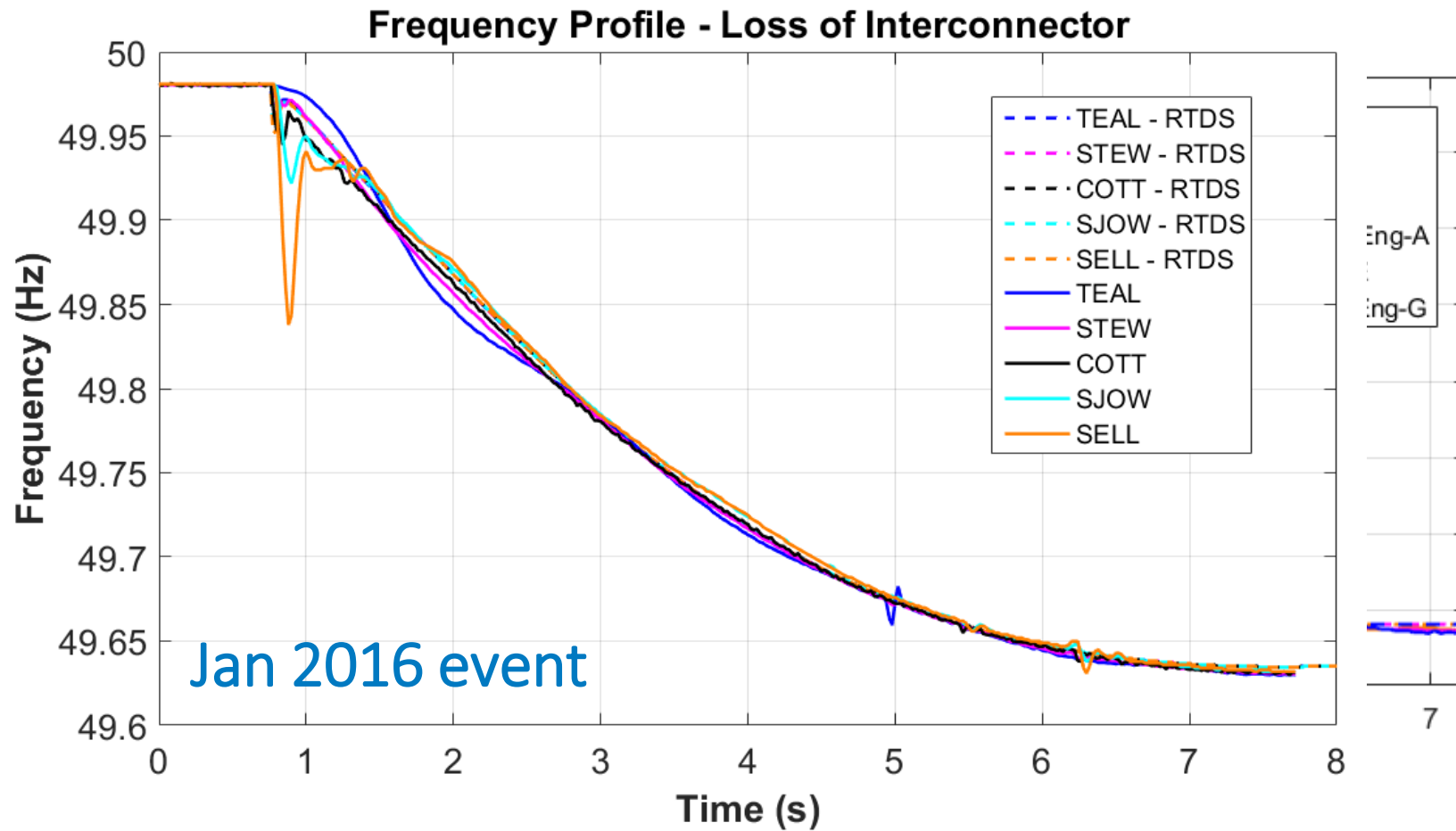
- Historic grid events are used to validate the dynamic model response.

- Focus on regional variations in inertia and rate of change of frequency (RoCoF).

P-HiL Interface Control

- Frequency and phase control loop are used to synchronise the MG set voltage phasor and to the corresponding phasor at the common RTDS bus.

- MG set response characterisation tests and offline modelling of the MG set were used to derive the control loop parameters.
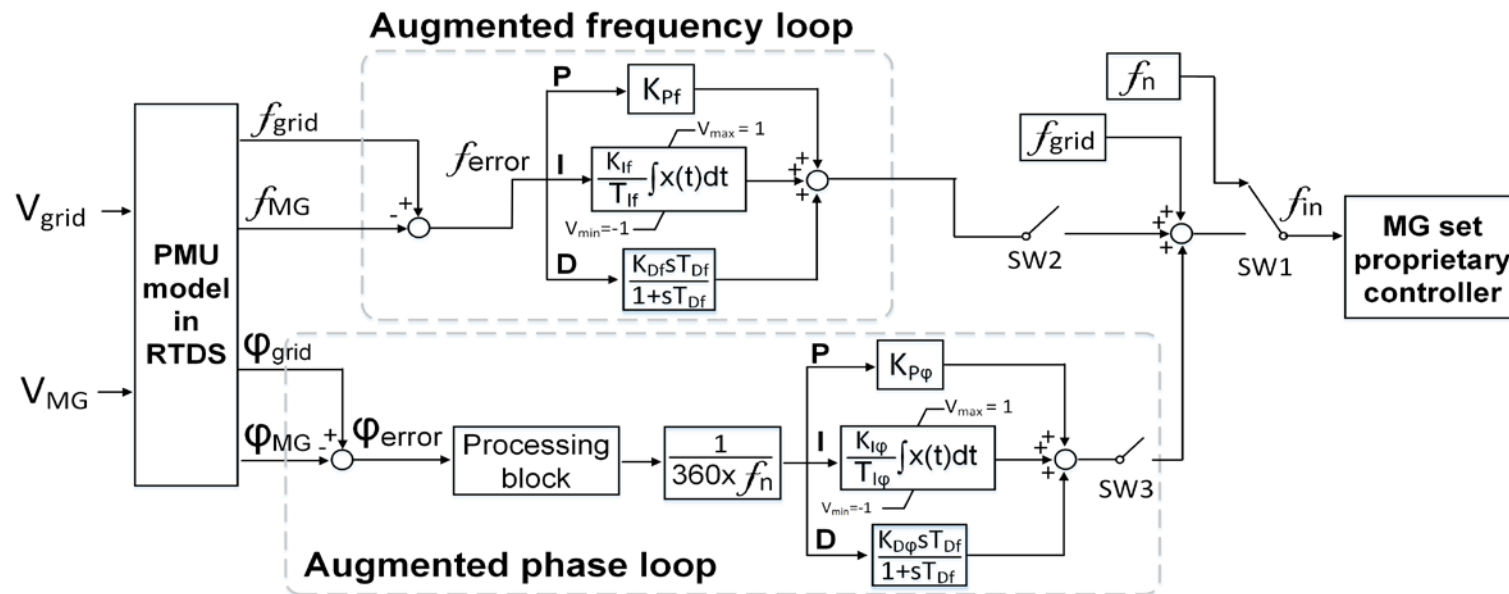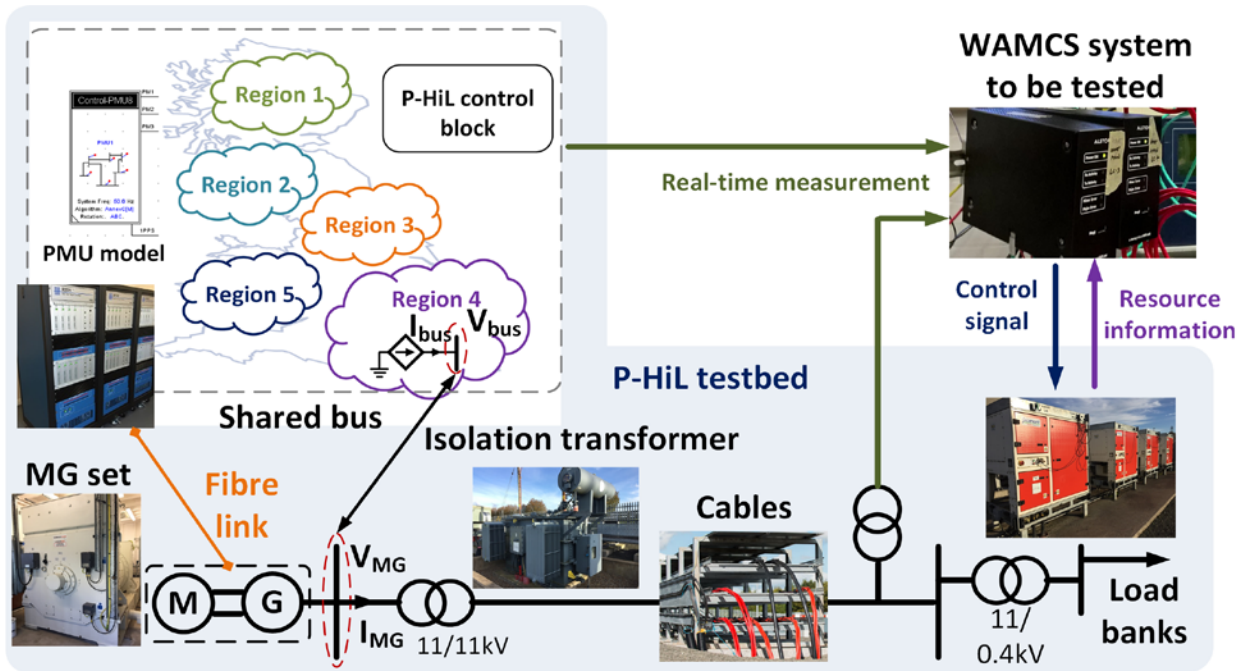
P-HiL Frequency and Phase Tracking

- Maximum state frequency and phase errors of 0.04Hz and 10° respectively.

- Maximum steady state frequency and phase errors of 0.01Hz and 3° respectively.
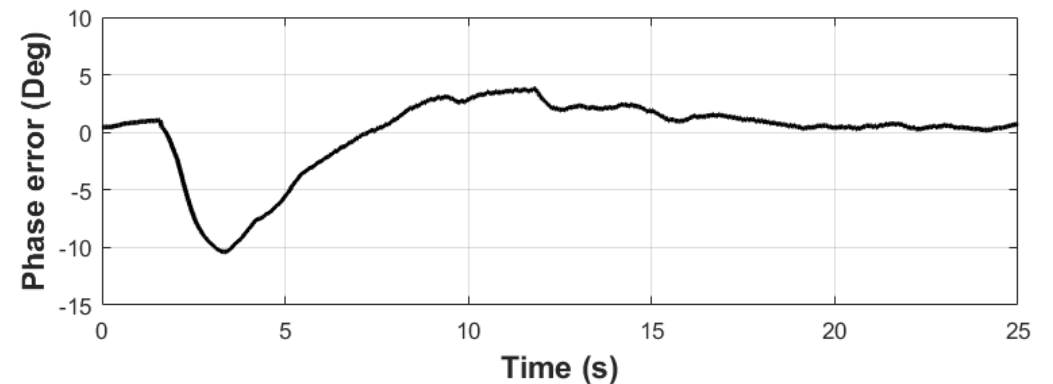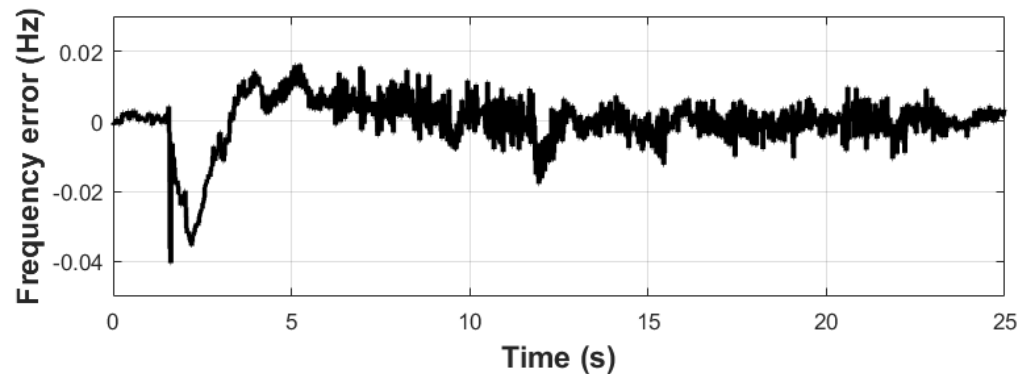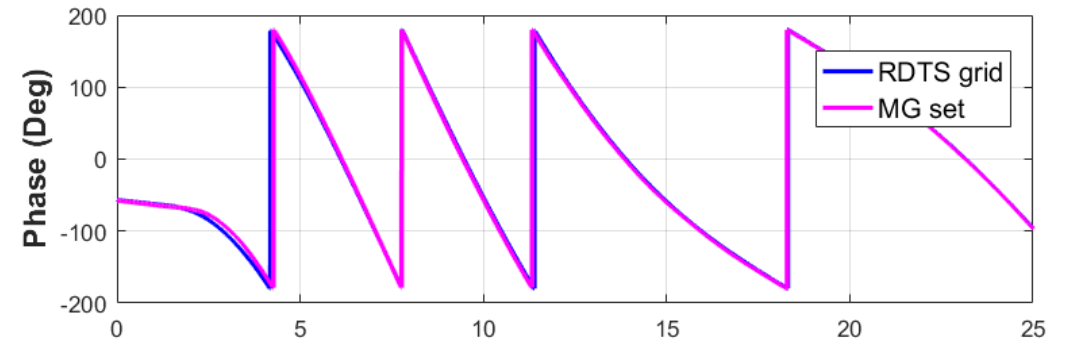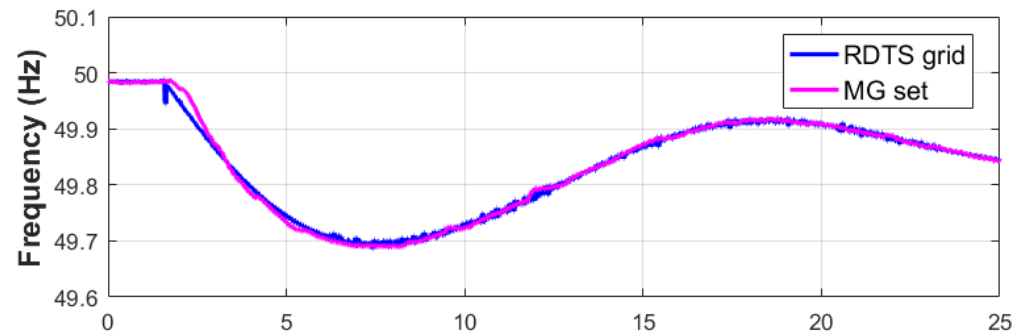
P-HiL Test Setup Integration

- GE Wide Area Monitoring and Control System (WAMCS) integrated with the P-HiL setup.

- Controllers are used to dispatch simluated and physical load banks in response to a frequency event.

- Dependability and stability testing of the full control scheme during frequency and voltage disturbances.

- Communications emulation will be used to study the impact of communications issues on the controllers' performance.

Planned Tests of Controller Performance

- Local mode operation during different RoCoF events.

- Wide area mode of operation during loss of generation events under different inertia initial conditions.

- Stability during fault induced voltage depression.

- Cascading loss of generation events.

- Communications latency, jitter and loss of link.

www.pndc.co.uk