

# Synchro Phasor Monitoring System

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Generator Forum 15<sup>th</sup> May



# Presentation Content

- Update on status of SPM system
- Use of SPM system during North-South Separation
- Use of system during Storm Darwin
- Use of SPM to observe generator behaviour during Testing
- Recent Power System Events of Concern



# SPM System Status Update

- 19 PMU's now operational
  - 14 in Ireland
  - 4 in Northern Island (Coolkeeragh \* 2, Moyle & Castlereagh House)
  - 1 in UK on East West Interconnector
  - Additional Units planned for NI
- Additional recorders installed in Ireland with PMU capability will be connected to the SPM system as bandwidth required to stream data becomes available
- Real Time Phasor Data now available to NCC and will be available to CHCC in near future

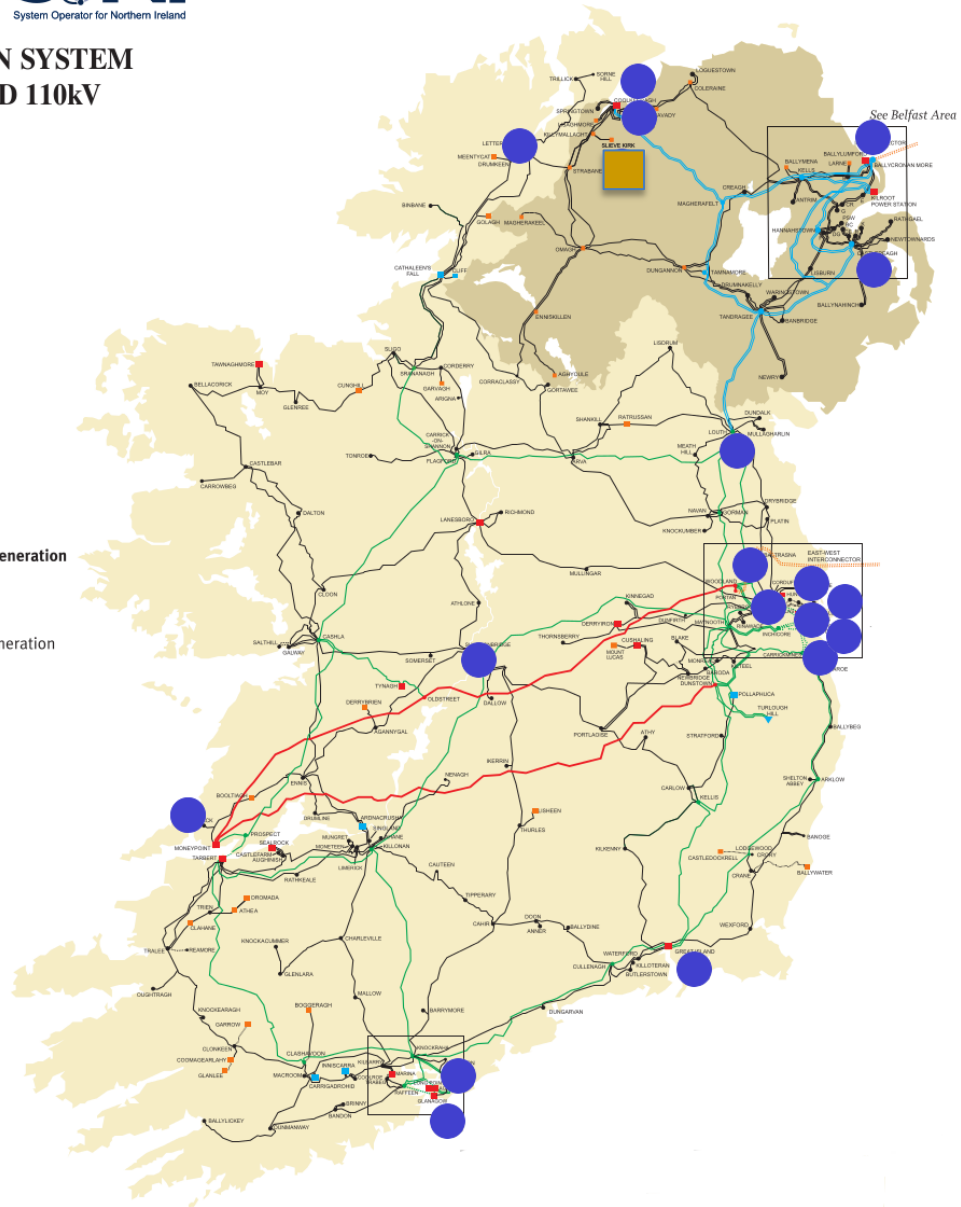


# TRANSMISSION SYSTEM

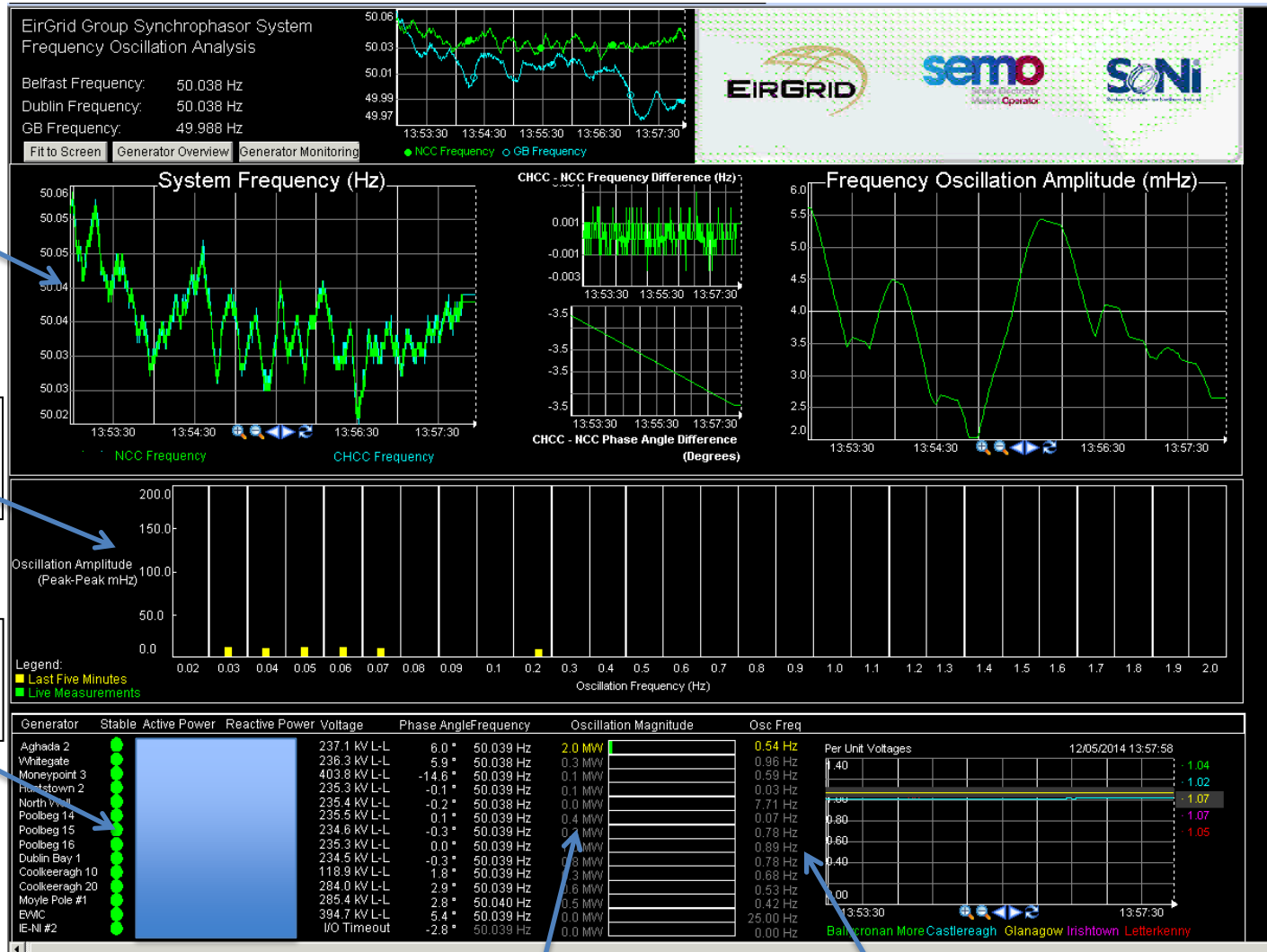
## 400, 275, 220 AND 110kV

### JANUARY 2014

- 400kV Lines
  - 275kV Lines
  - 220kV Lines
  - 110kV Lines
  - - - 220kV Cables
  - - - 110kV Cables
  - - - HVDC Cables
  - 400kV Stations
  - 275kV Stations
  - 220kV Stations
  - 110kV Stations
- Transmission Connected Generation**
- Hydro Generation
  - Thermal Generation
  - ▼ Pumped Storage Generation
  - Wind Generation



# Control Centre Frequency Oscillation Monitoring Display



System Frequency Measurements

Frequency Spectrum Analyser

Generator Stability Status

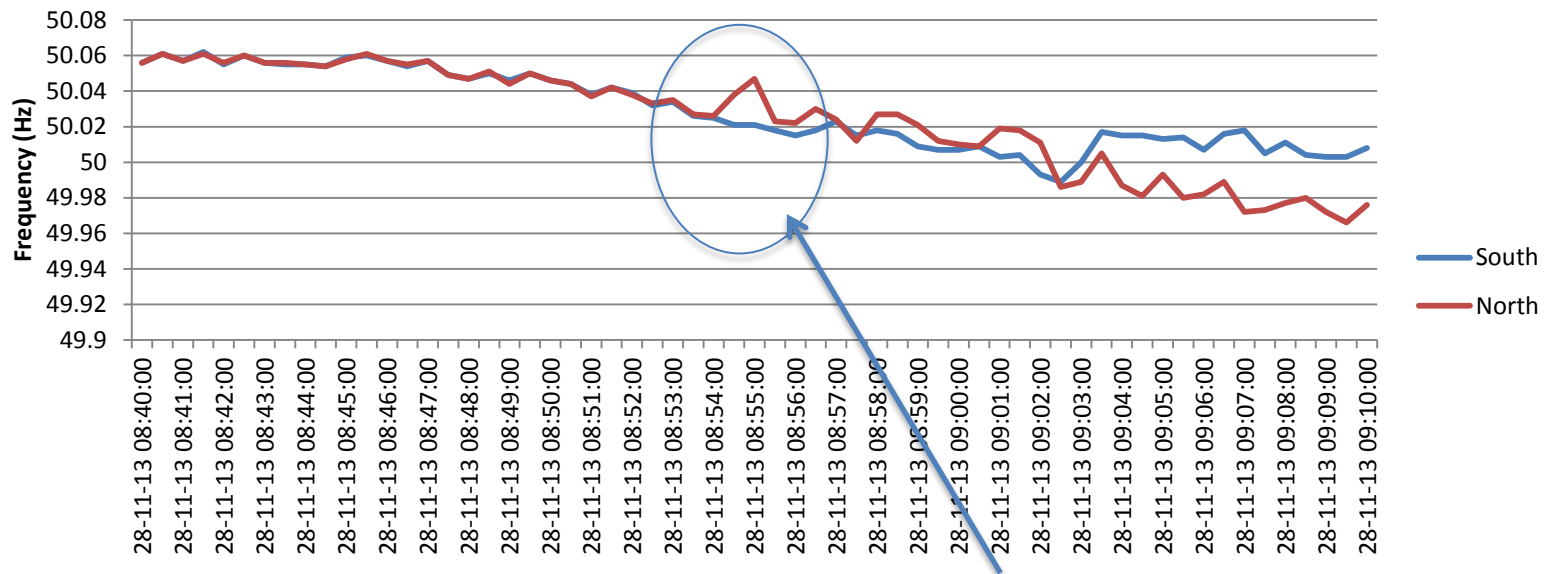
Oscillation Magnitude (MW) & Frequency



# North-South system Separation 28<sup>th</sup> Nov 2013

## Forced Outage of Louth-Tandragee 275 kV Interconnector

### System Frequencies pre/post System Separation

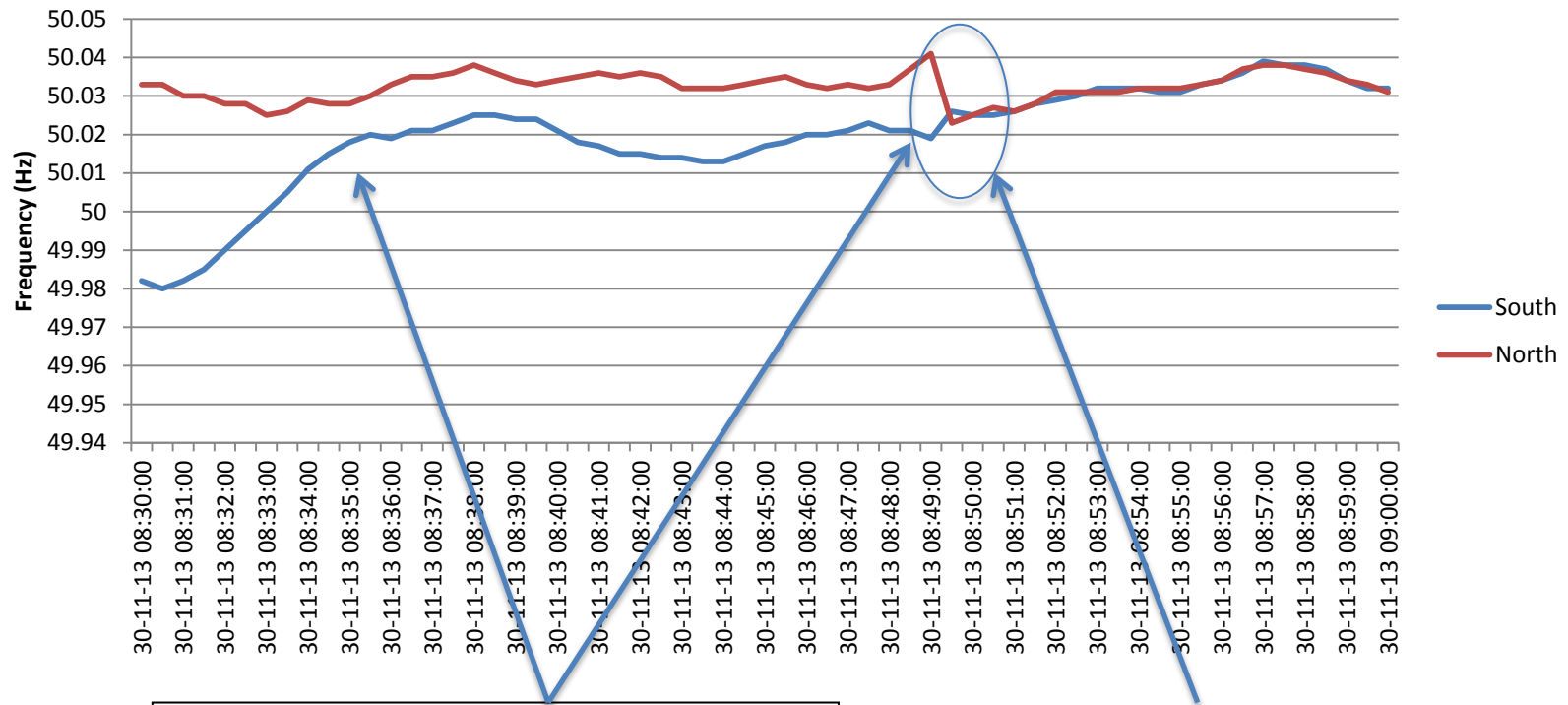


Moment of Separation



# North-South Re-Synchronisation 30<sup>th</sup> Nov 2013

## System Frequencies during System Re-synchronisation



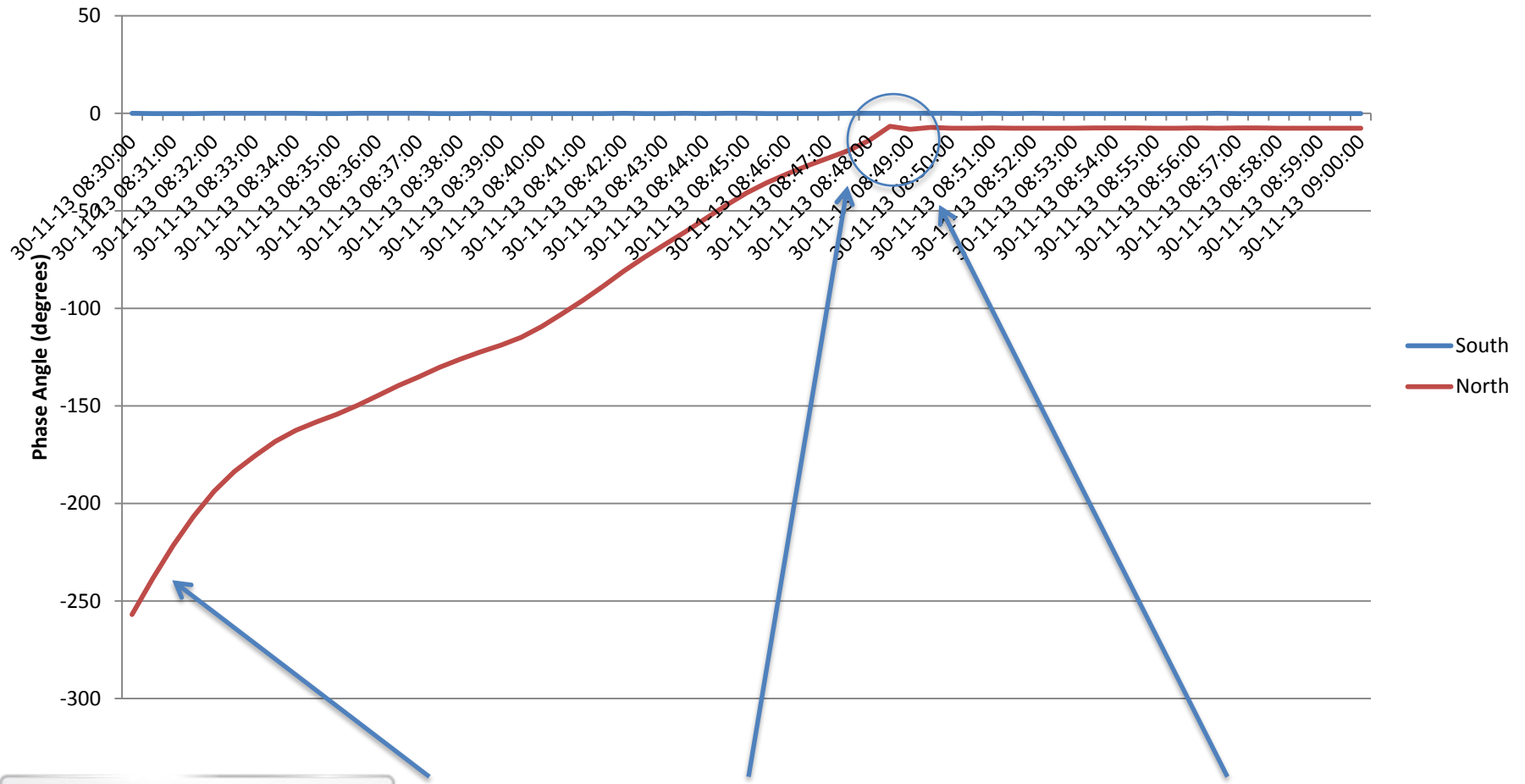
Matching of System Frequencies

Moment of Re-Synchronisation



# North-South Re-Synchronisation 30<sup>th</sup> Nov 2013

## Voltage Phase Angles during System Re-synchronisation



Matching of System Angles

Moment of Re-Synchronisation





# The Synchro-phasor Monitoring System Provides Control Centre With

- Immediate Identification of System Splits
  - Information of the state of each sub system
  - Means to direct efforts when re-synchronising two parts of the system
- Generator MW & MVA<sub>r</sub> output
- Bus Voltages / Frequencies / Phase angles
- Oscillation magnitudes and frequencies
- Indication of Faults, Fault Types and Durations
- Partial Backup for Scada/EMS failure

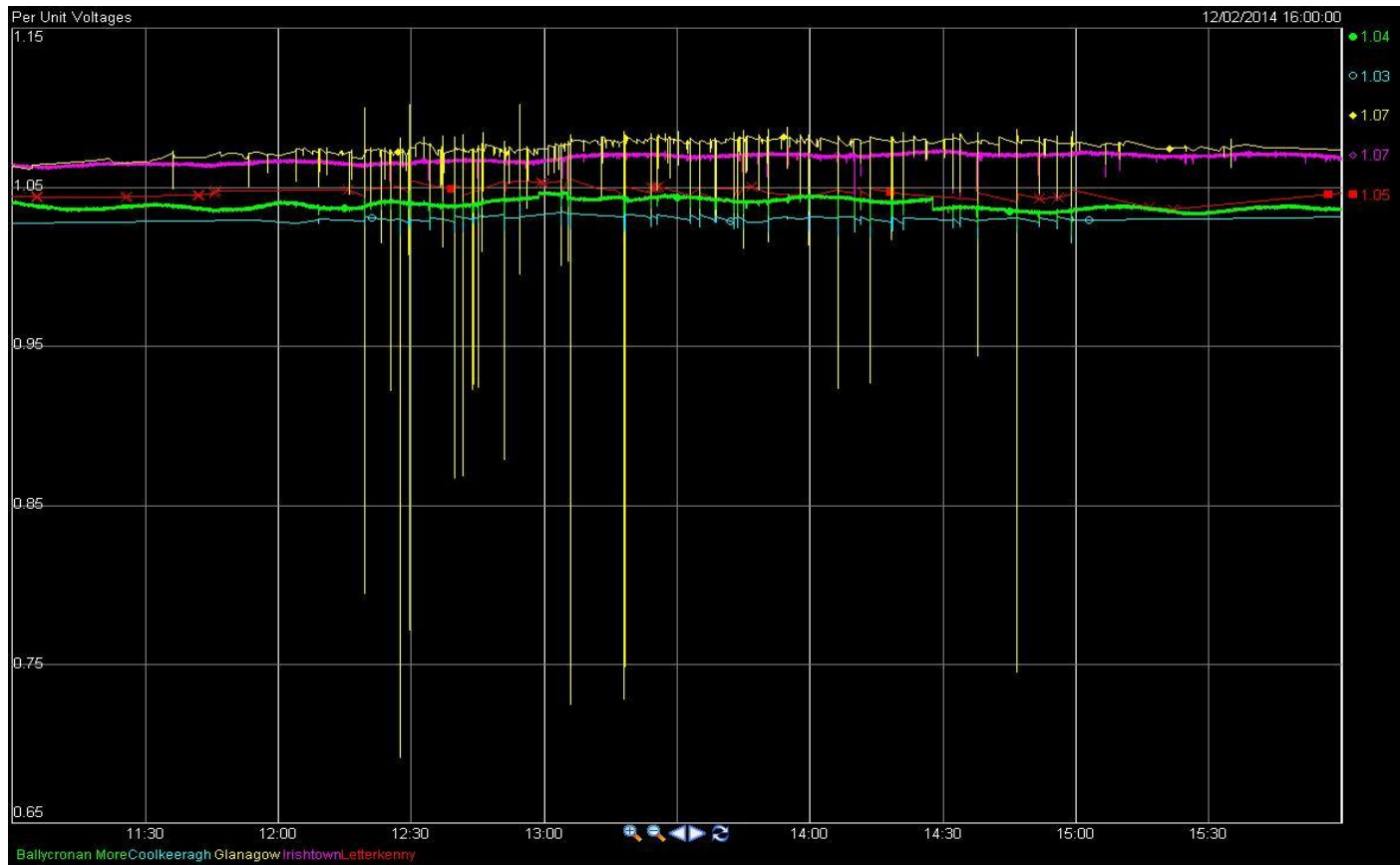


# Use of Phasor Monitoring system during Storm Darwin 12<sup>th</sup> February

- 67 faults on 110 kV System from 11:36 to 16:21
  - Seven 110 kV load stations disconnected
  - Three 110 kV wind farms disconnected
- Eight lines forced out of service at end of storm
- All generators rode through all faults



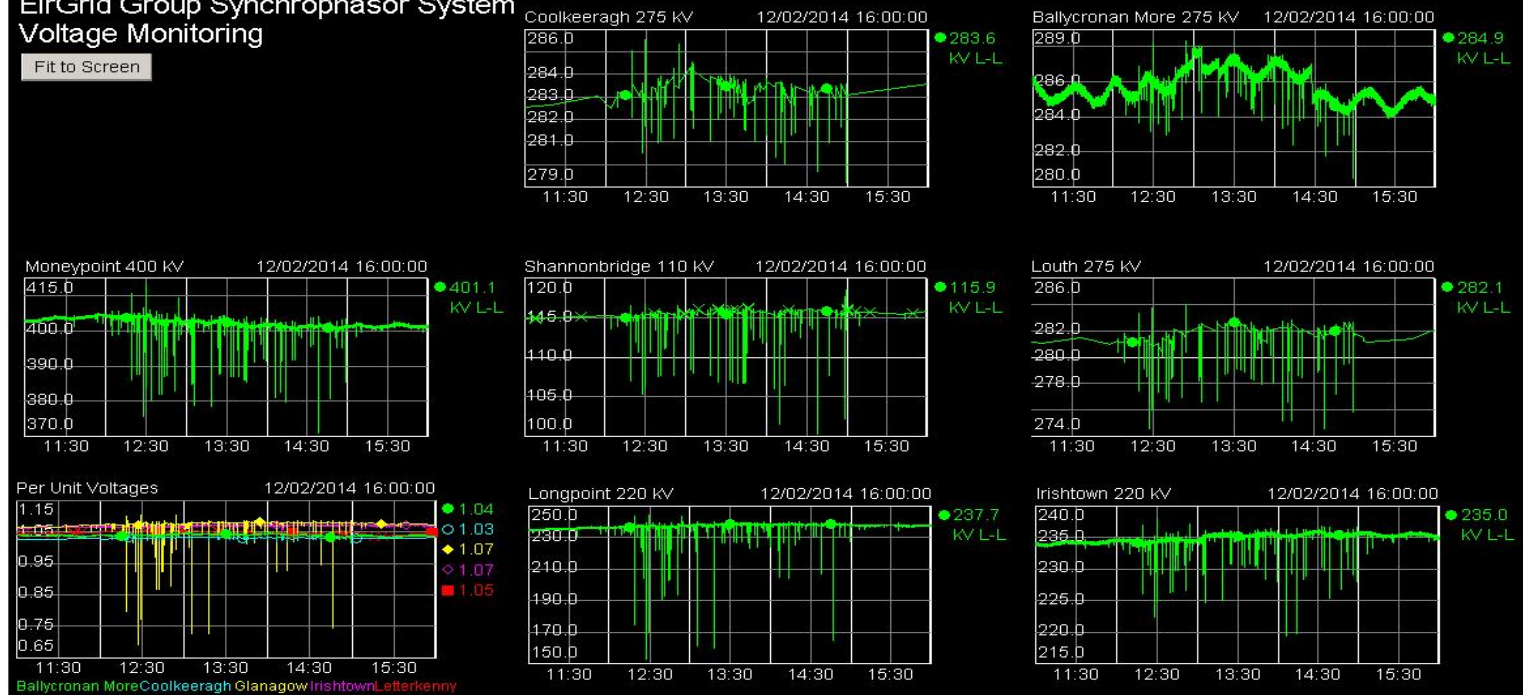
# Voltage Dips Across the Network 11:30 to 15:30



# Impact at various networks nodes available to operators seconds after fault

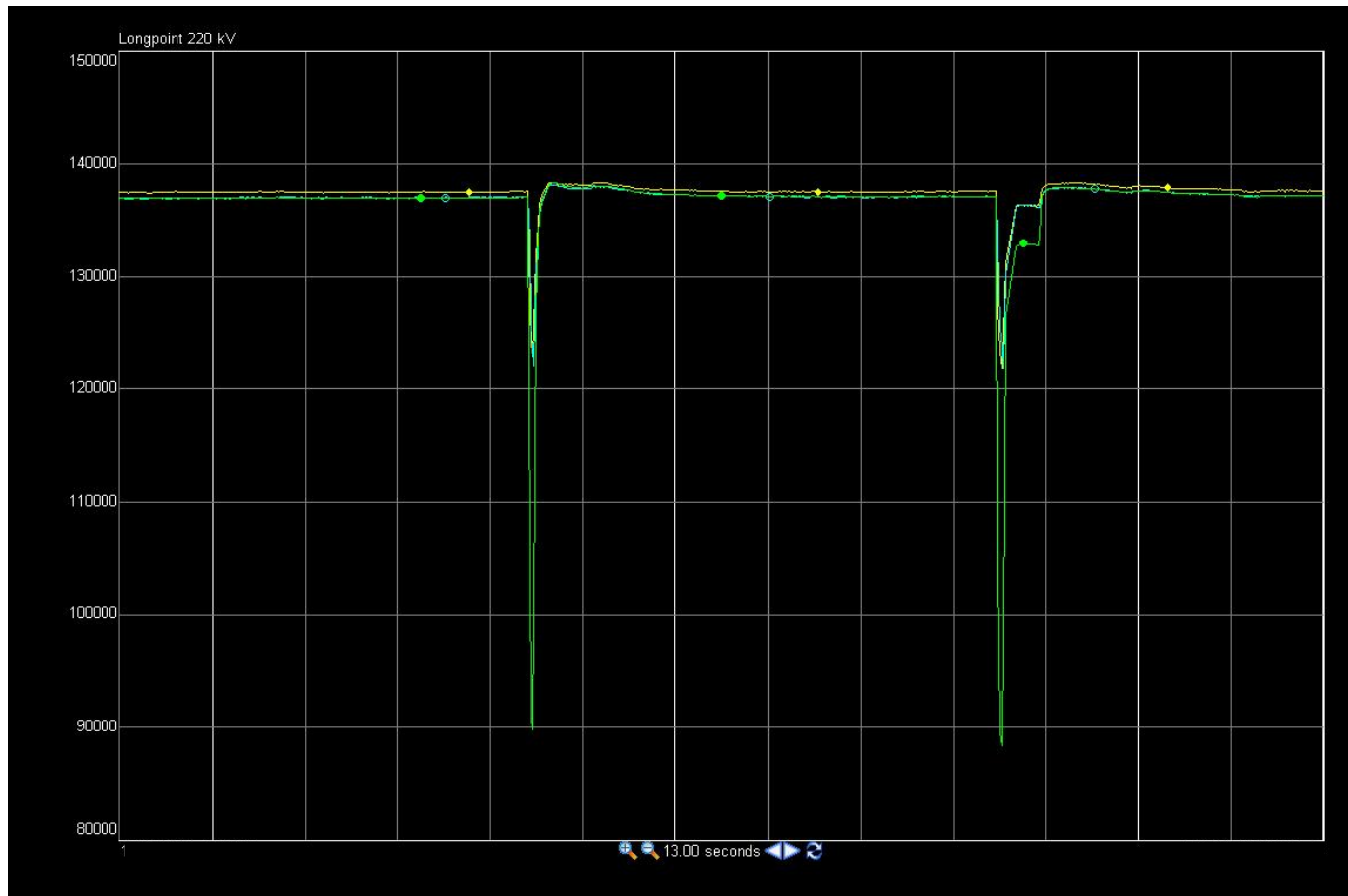
## EirGrid Group Synchrophasor System Voltage Monitoring

Fit to Screen



# Line Trip, Auto-Reclose & Trip

1 Ph to E fault, line structure okay, attempt restoration

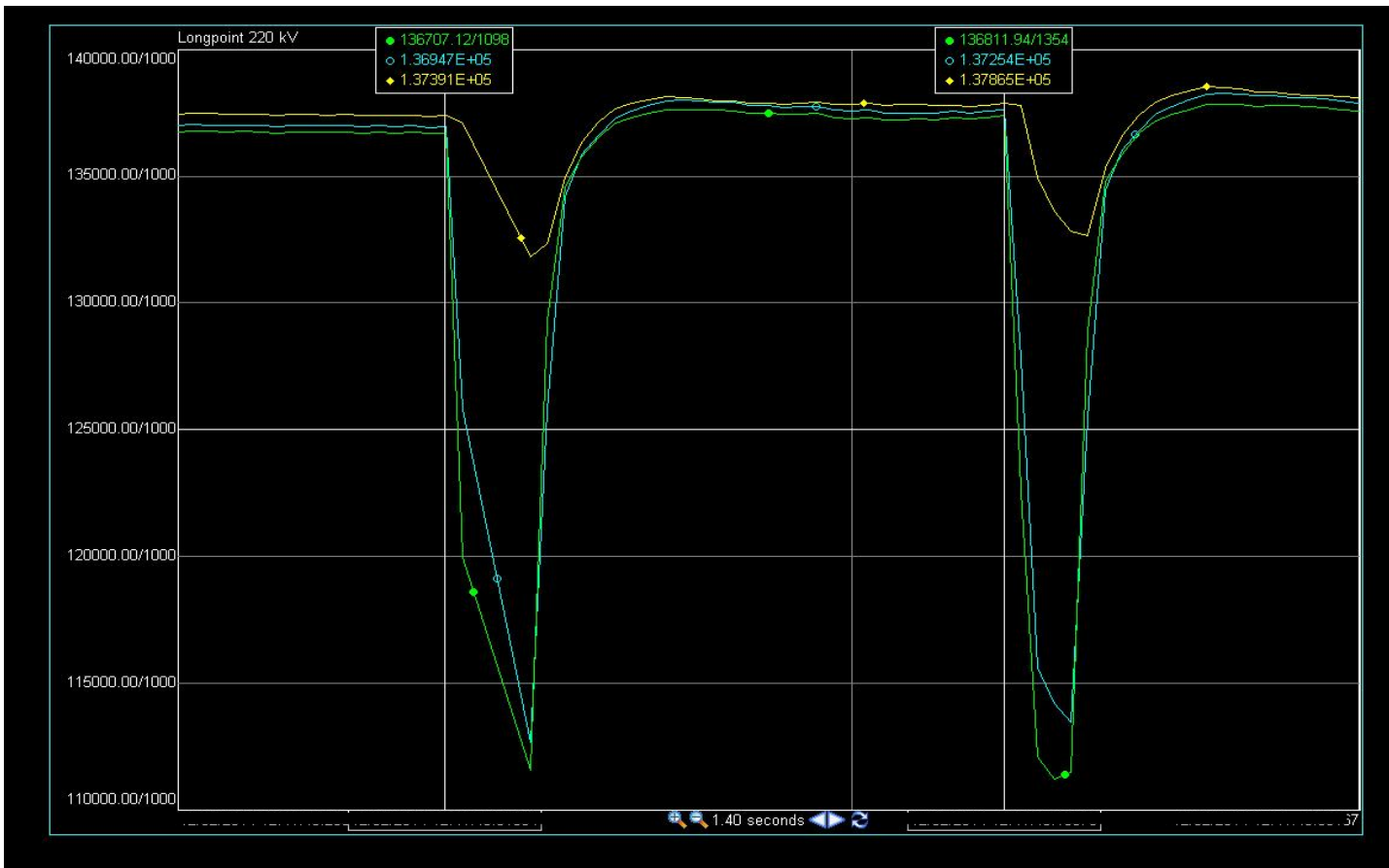


1 s per division



# Line Trip, Auto-Reclose & Trip

Ph to Ph fault , possible structural damage, no restoration attempt



~ 0.5s per division



# Fault evolving from 1 to 2 to 3 phase

(suggest structure failure thus no attempt to restore)



# Use of Phasor Monitoring system during Storm Darwin 12<sup>th</sup> February

- SPM system can provide detailed fault information to control centre in real time
- This supplements existing information such as Protection relay signals
- New information is graphical thus faster and easier to interpret
  - In many instances can reduce decision making time



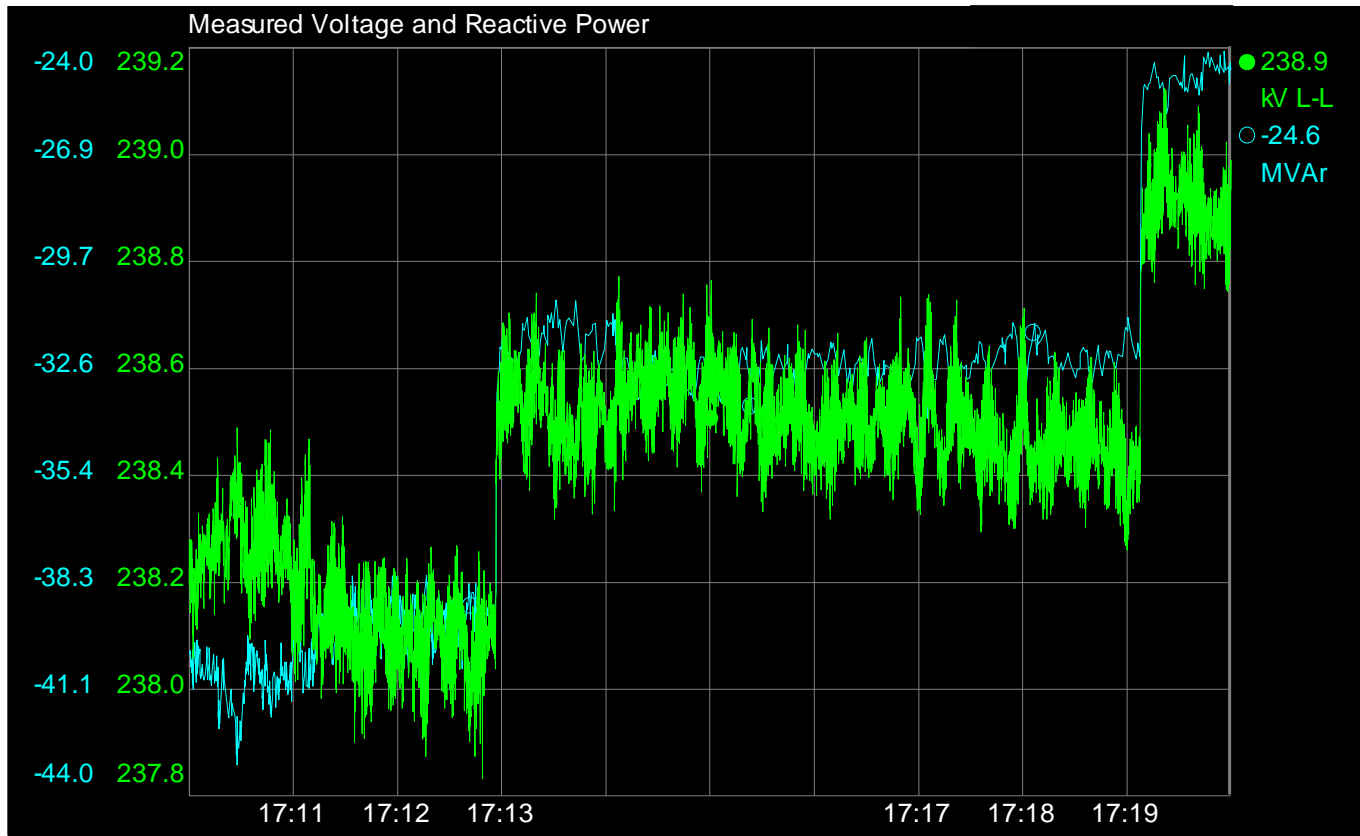


# Use of SPM to observe generator behaviour during Testing

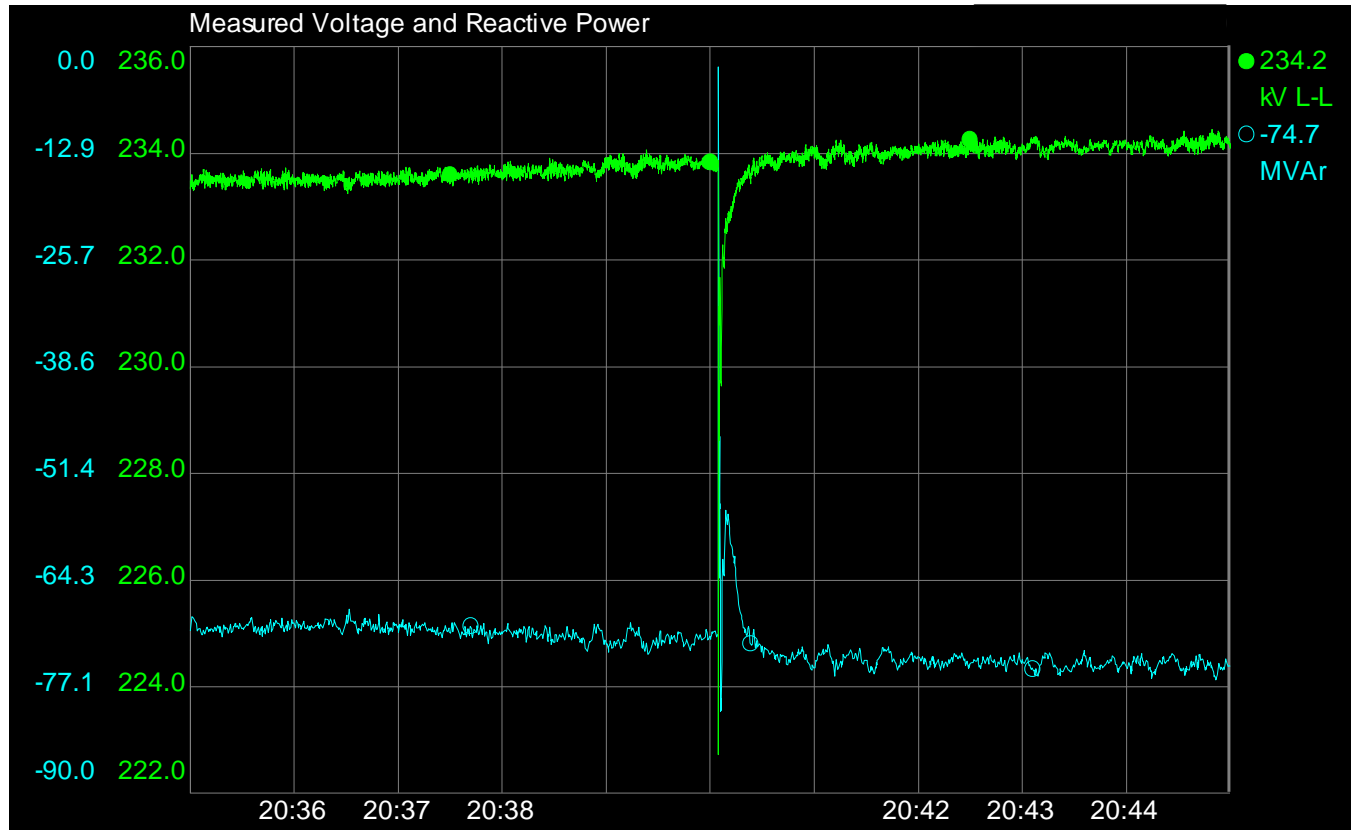
- The SPM now allows observation of generator testing in real time
  - Any issues the machine is causing for the system or other generators can be observed
- Should allow for more secure operation of the system when tests with significant impact potential are being carried out
- Allows decisions to be made on continuing with test programme or pausing to investigate issues



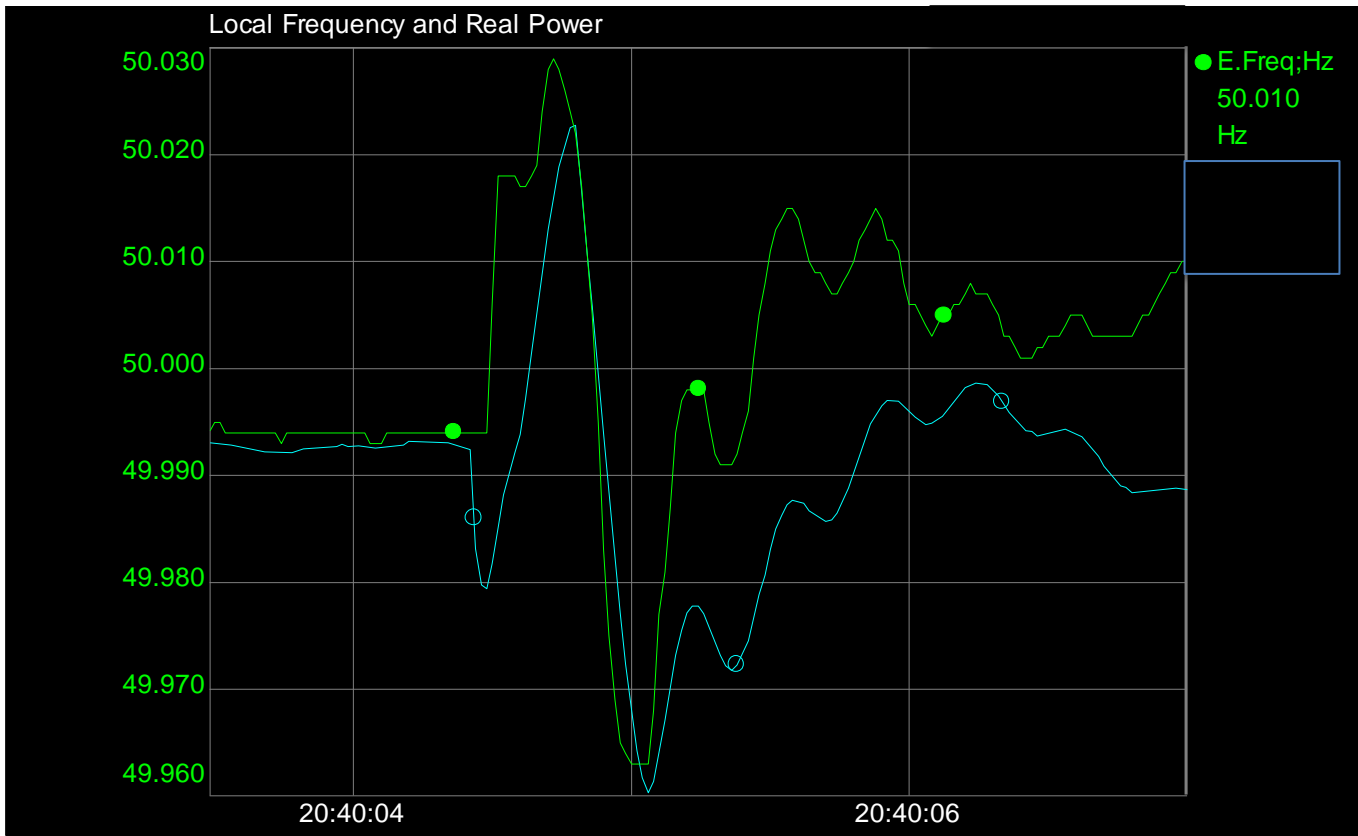
# Example of Setpoint Step Change to AVR



# Reaction of Generator MVar output to Disturbance introduced by Transformer Switching



# Reaction of Generator MW Output Disturbance introduced by Transformer Switching

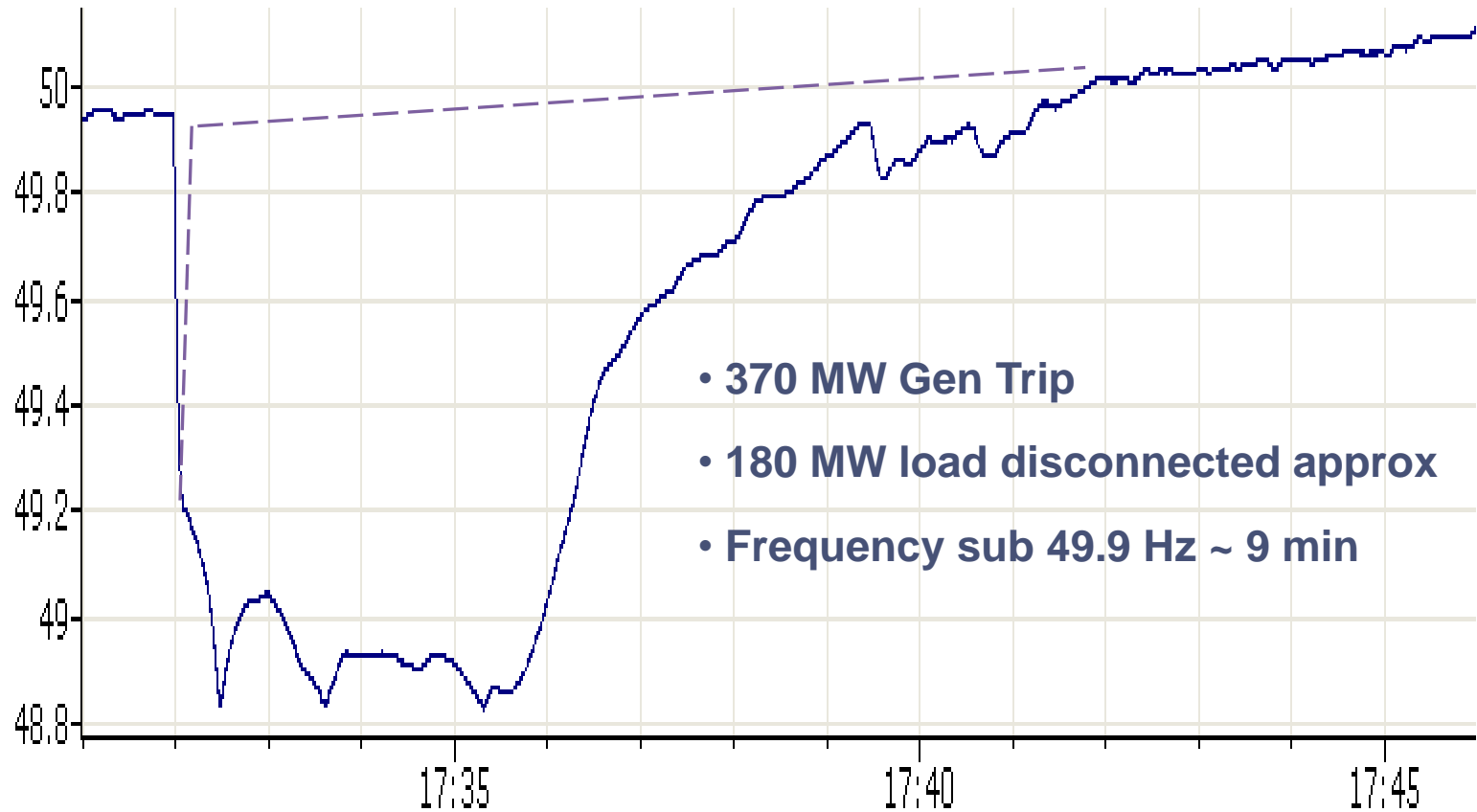


# Recent Incidents

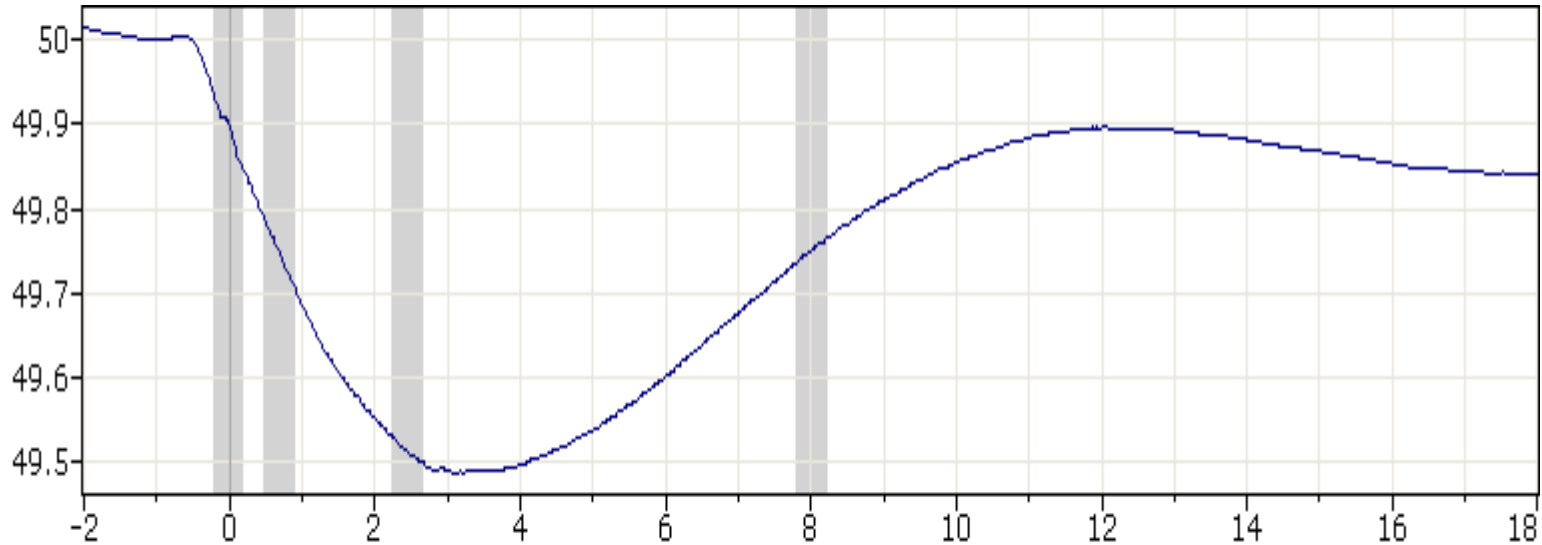
- Two Major Incidents currently under Investigation
  - 22<sup>nd</sup> April Under-frequency Load Shedding following generator trip
  - 27<sup>th</sup> April Major System Oscillation following generator trip



# System Frequency 22 April 2014 17:31 to 17:46

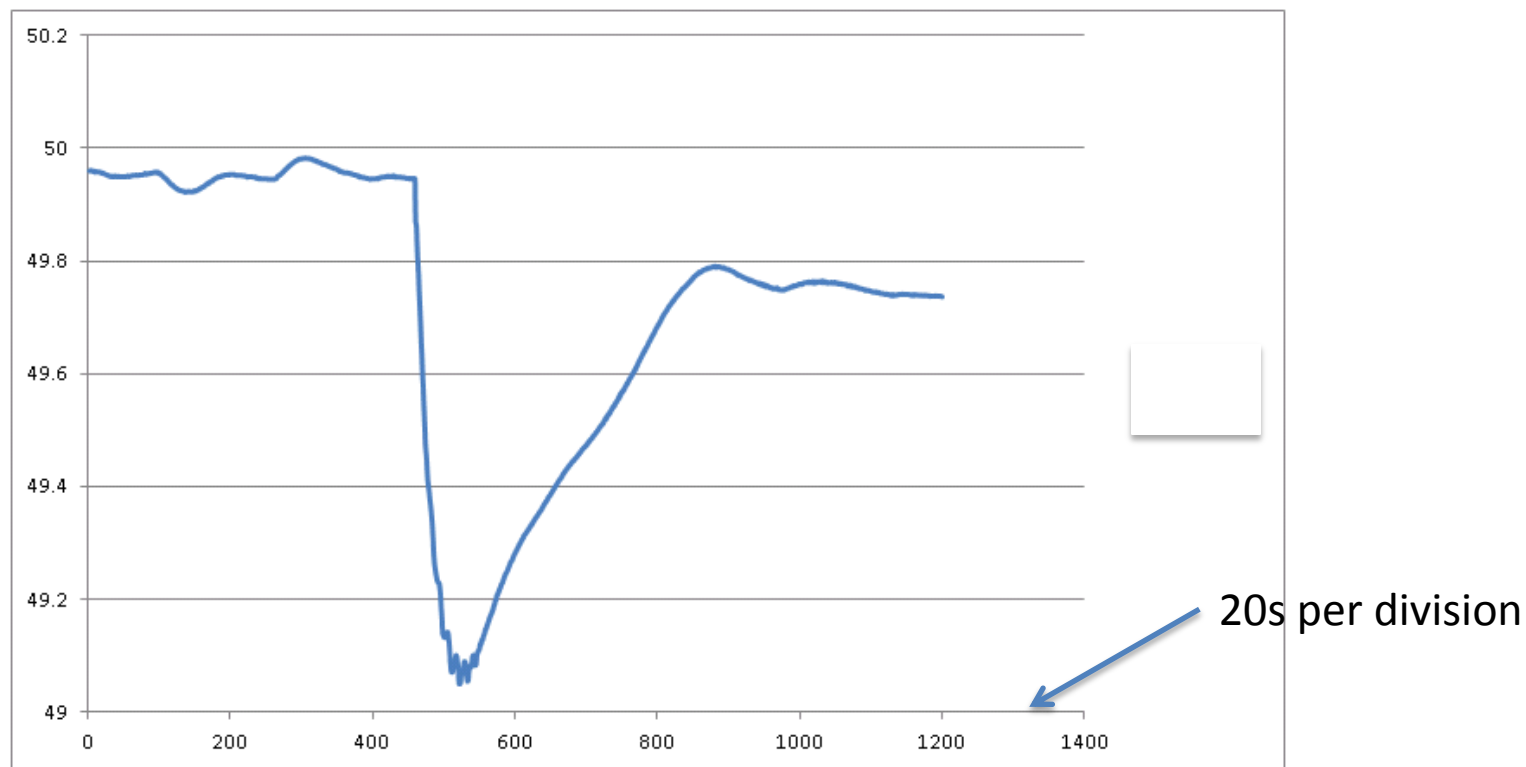


# Comparison Event



- **357 MW Trip 27 May 2013**
- **Frequency recovered to 49.9 Hz ~ 9 seconds post Nadir**

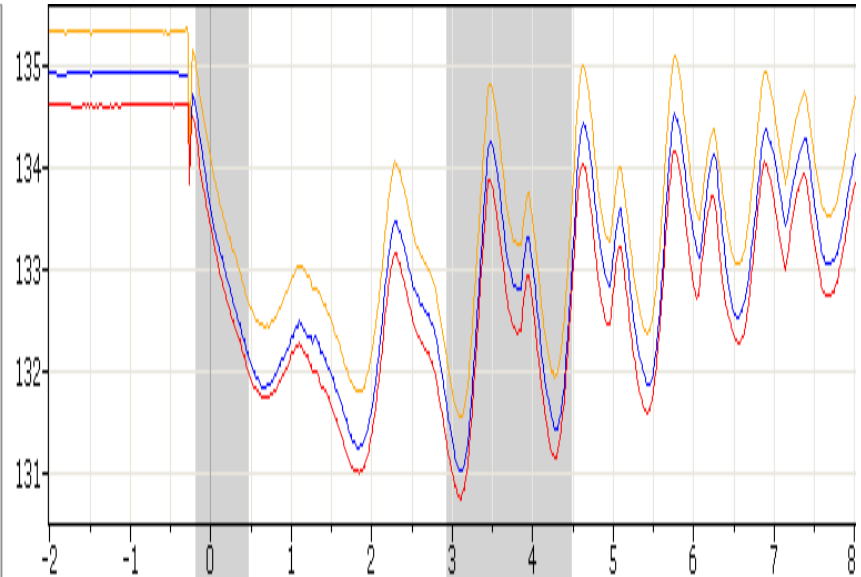
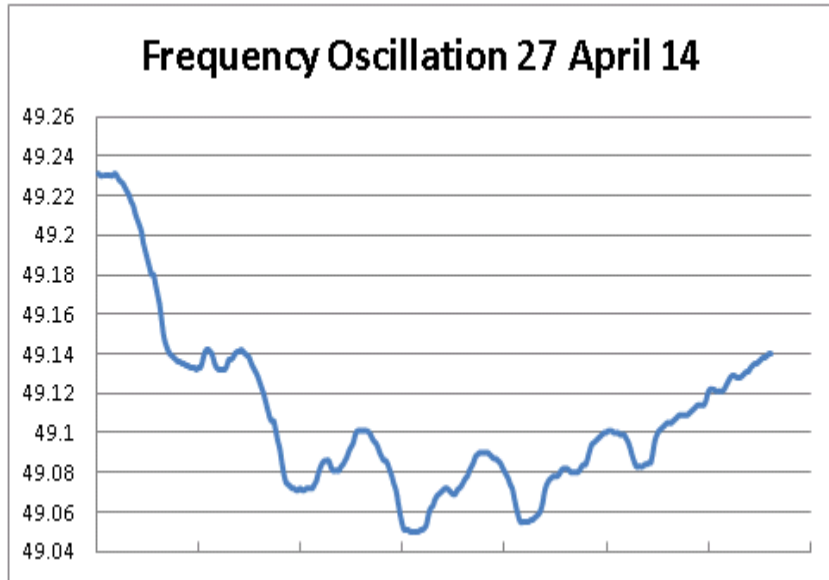
# System Frequency 27 April 2014 21:40



- 370 MW Trip 27 April 2014
- Severe Oscillation in generator outputs around Nadir



# Frequency & Voltage Oscillations



# Looking Ahead

- Trend is to have fewer conventional units committed than in the past
- No Margin for underperformance of any unit
  - In terms of reserve provision, stability, fault ride through, voltage support
- EirGrid & Generators to Collaborate on
  - More robust testing of machine capability and dynamic performance
  - Enhanced Performance Monitoring
  - Linking payments to actual performance with the potential for declaring services unavailable following evidence of under performance
  - Incentives to deliver the required performance



Thanks for your Attention

Questions



