

Low Frequency System Oscillations

Raymond Doyle

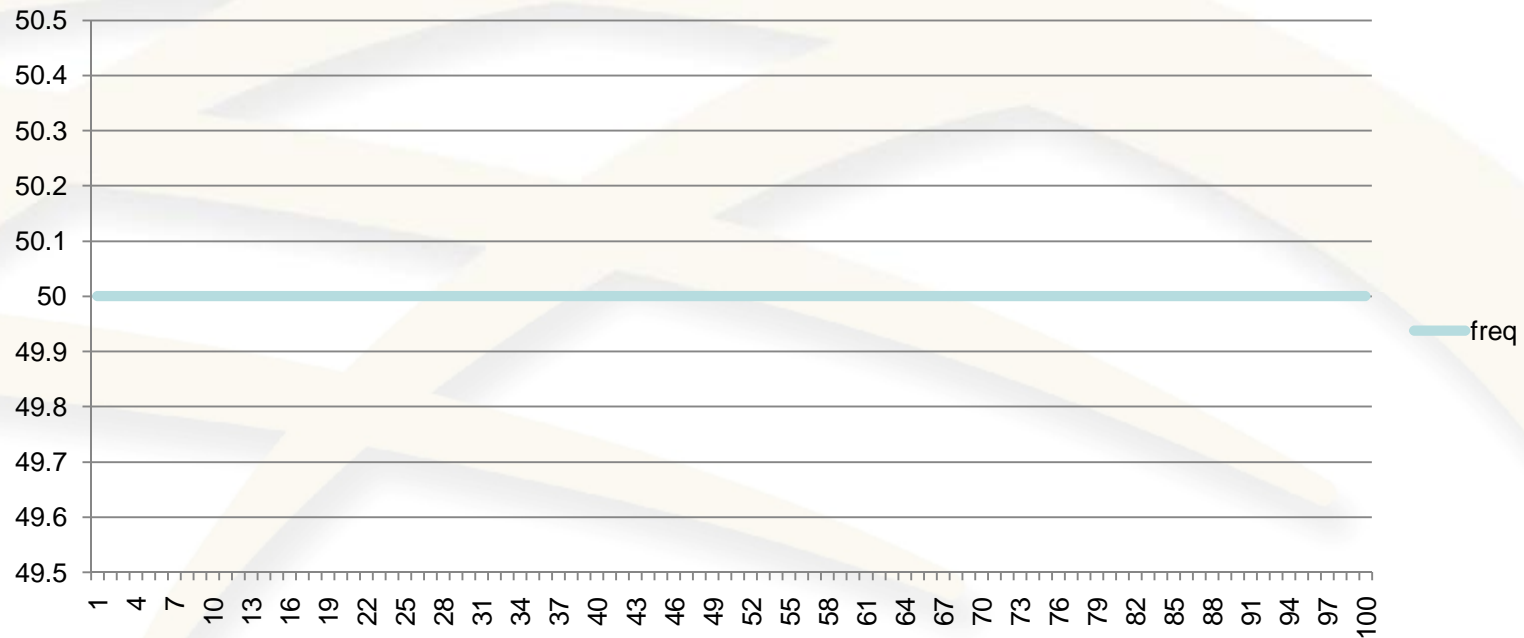


What are low frequency oscillations?



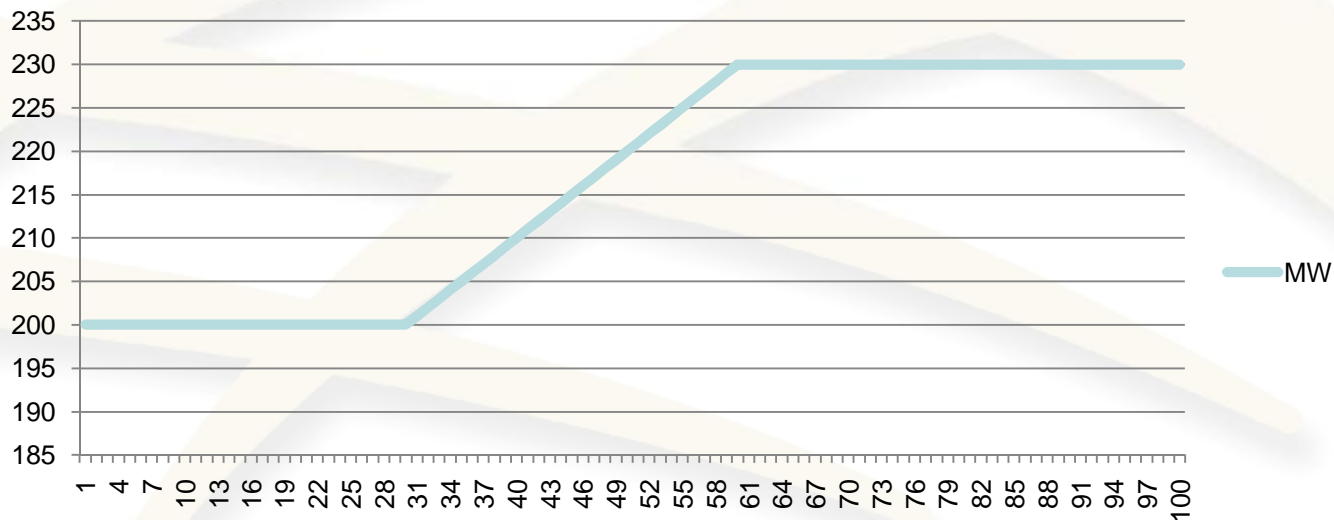
What are low frequency oscillations?

**Idealized System Frequency
Under Normal conditions**

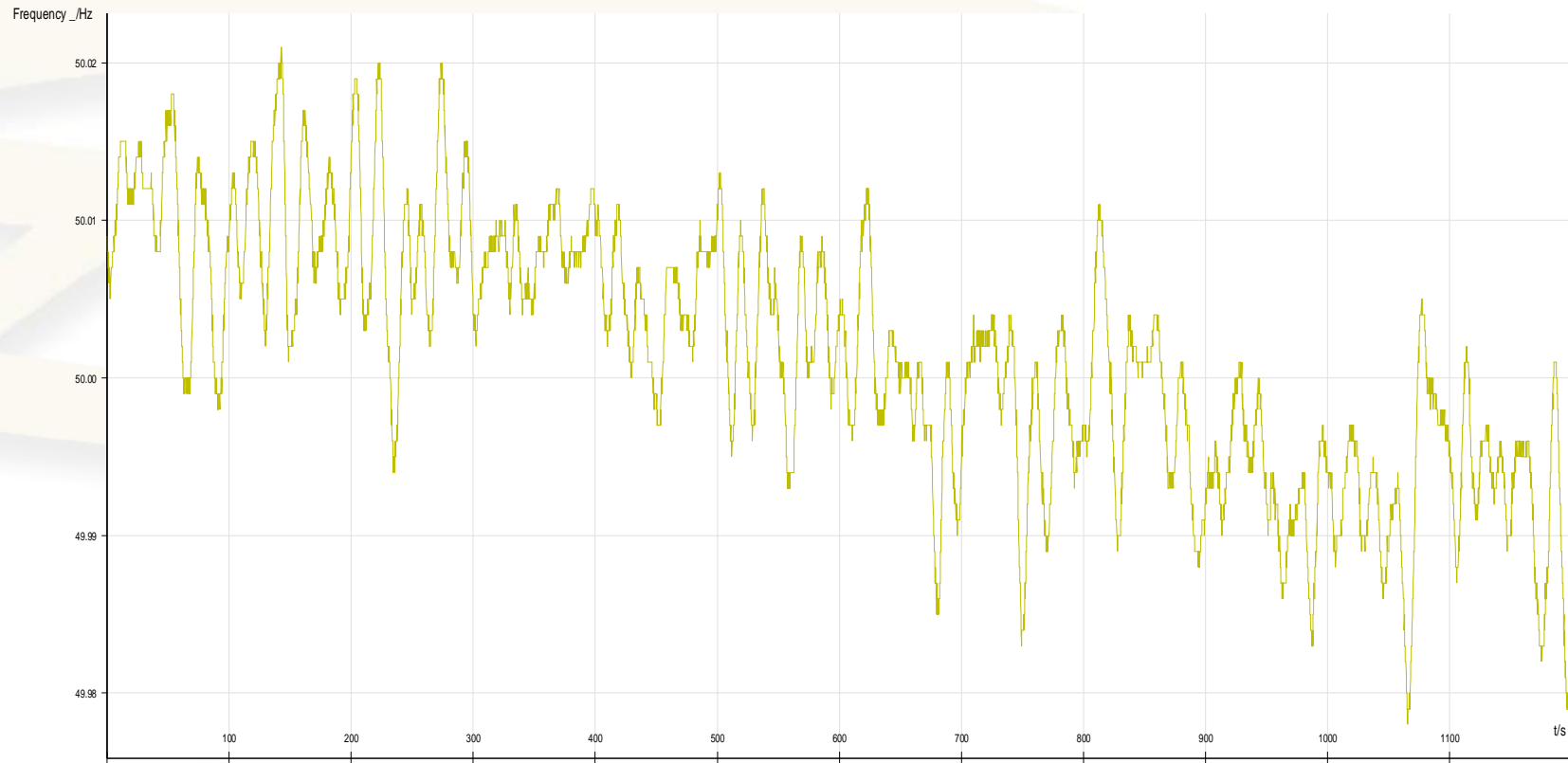


What are low frequency oscillations?

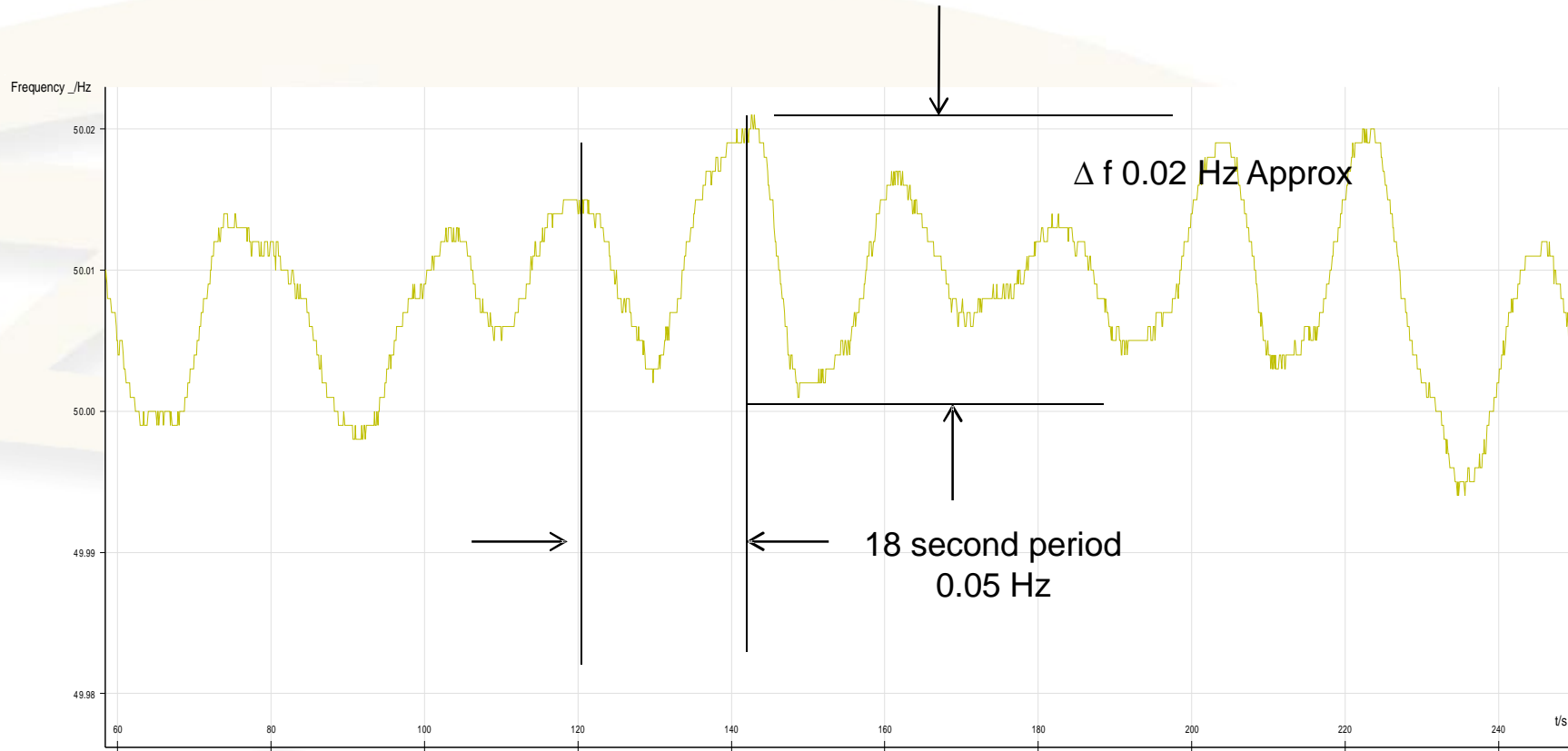
Idealized Generator Output Under Normal Conditions



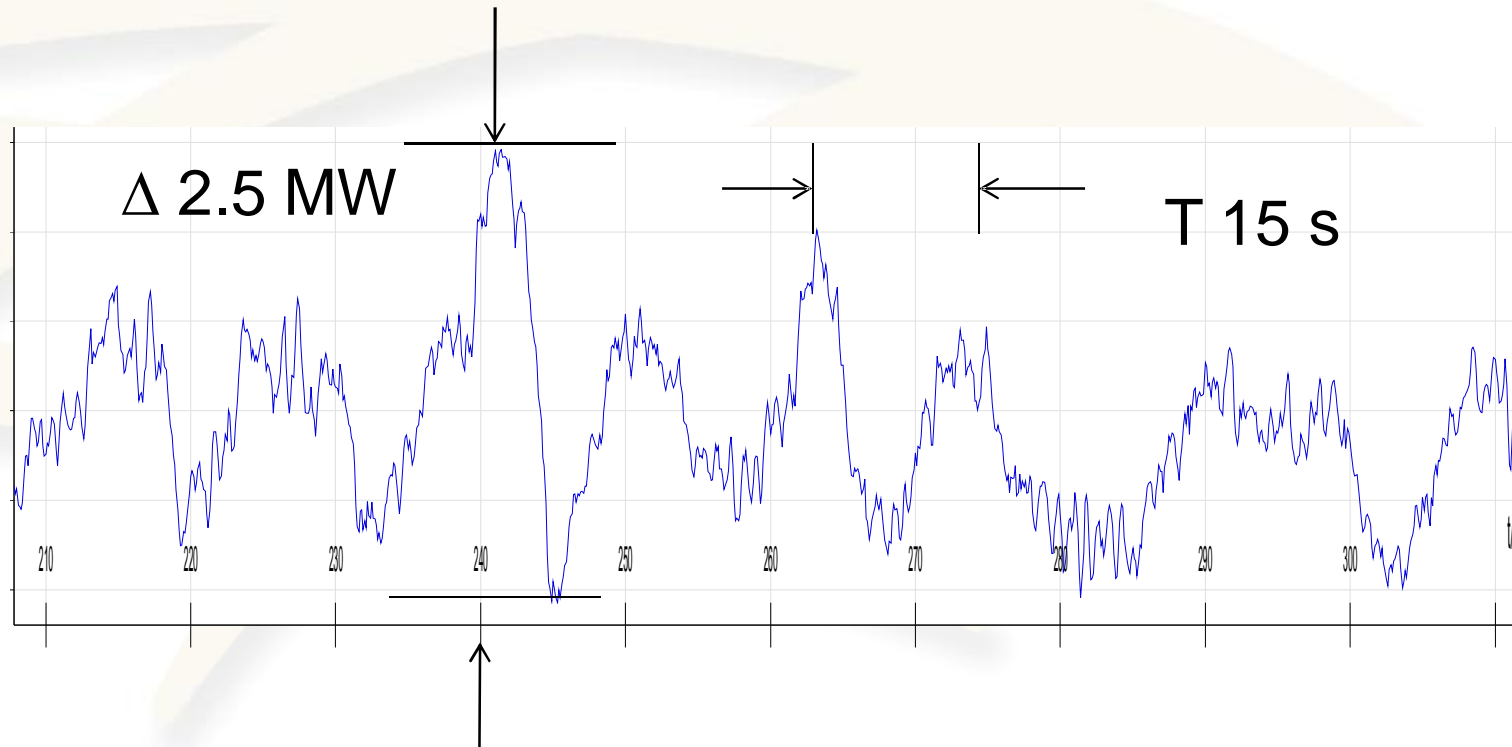
Actual Frequency Trace



Slow Low Magnitude Oscillation in System Frequency



Actual Generator MW output



Background

- Until recently
 - Oscillation events rarely observed
 - Events due to single machine issues
- Now
 - Events occurring more frequently
 - Possible issues with a number of units or certain combinations of units

What's Changed?

- A low level background oscillation present on system
 - not attributable to any one generator
 - Present at low and high levels of wind generation
- A number of new Units on the System
- Newer Machines tend to have lower Inertia

What's Changed?

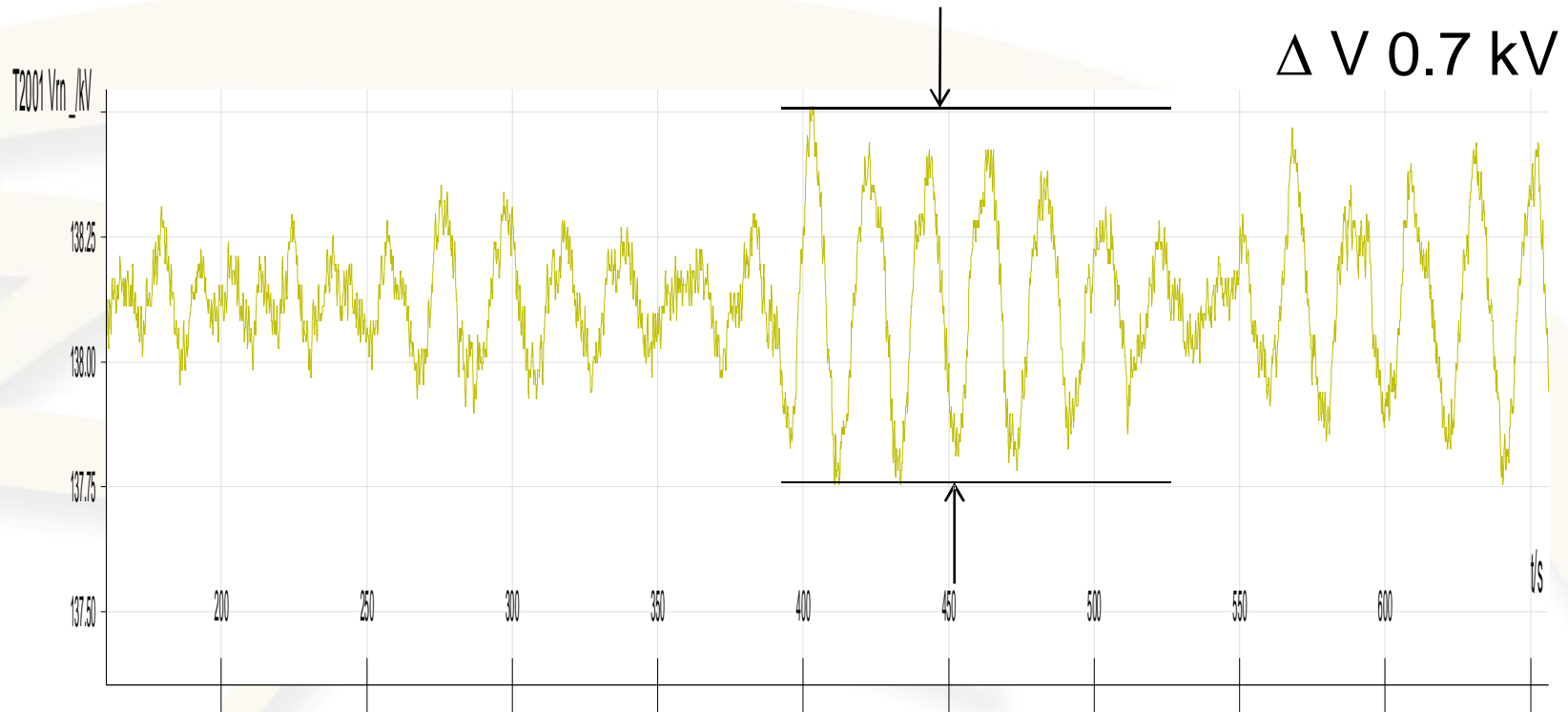
- Governor & Control System Replacement
- Improved Monitoring Capability
- Turlough Hill not available
- Increased Focus on units to deliver contracted MW reserve following u/f events

Issues

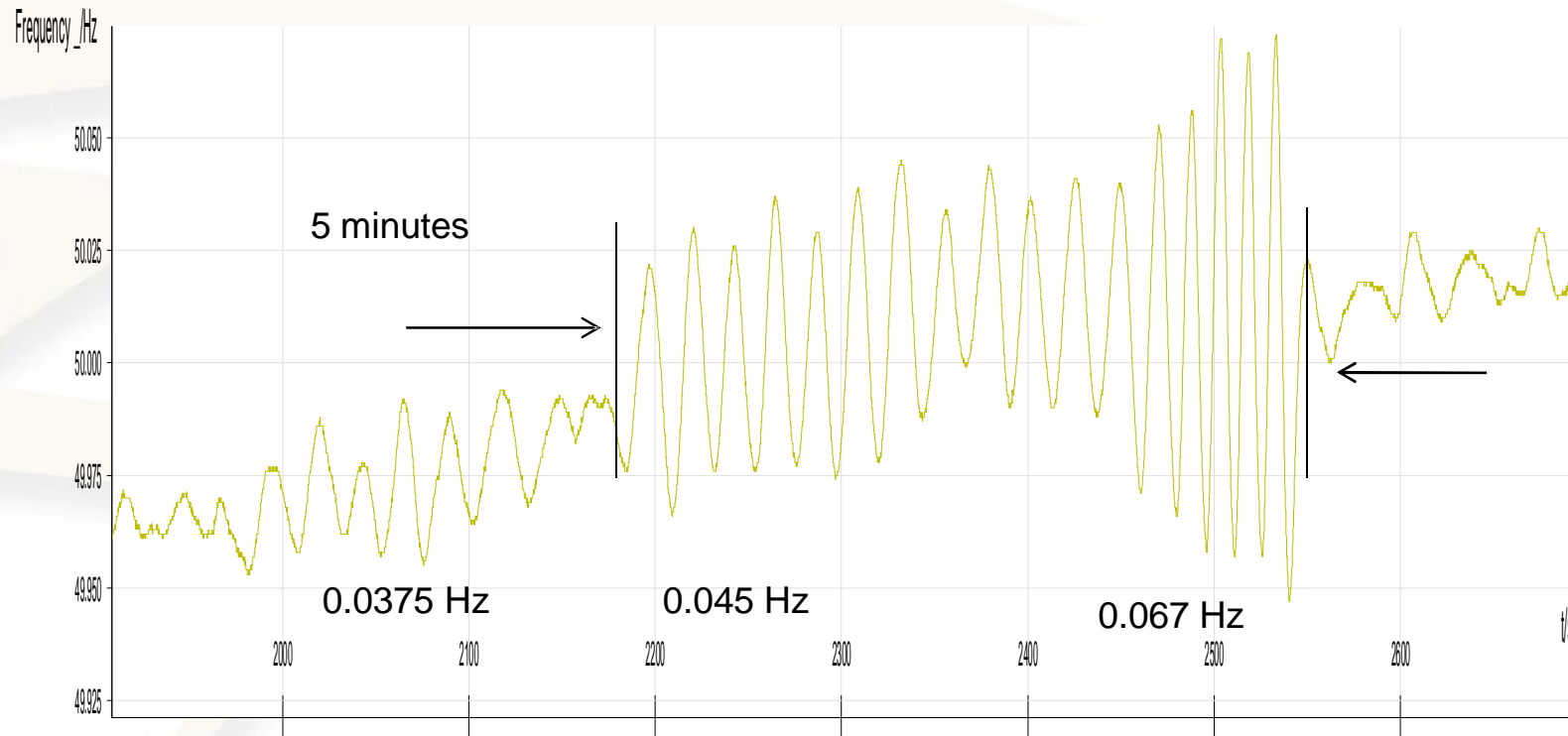
- Impacting on system Power Quality
 - Frequency & Voltage
- An oscillation may grow in amplitude and threaten the stability of the system
- Possible increased wear and tear on generator components

Impact on Power Quality

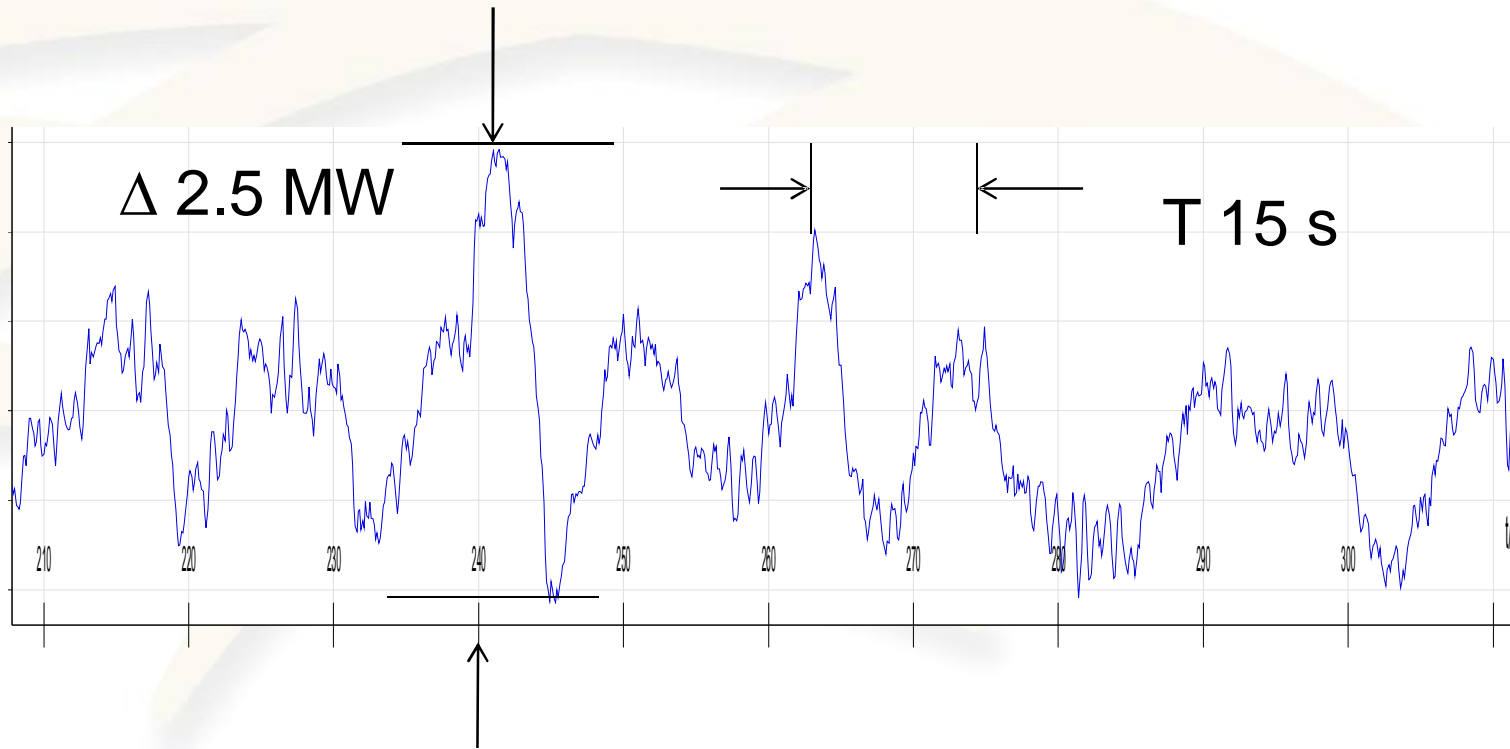
220 kV System Voltage RMS Variation



Oscillation Amplitude and Frequency Increasing

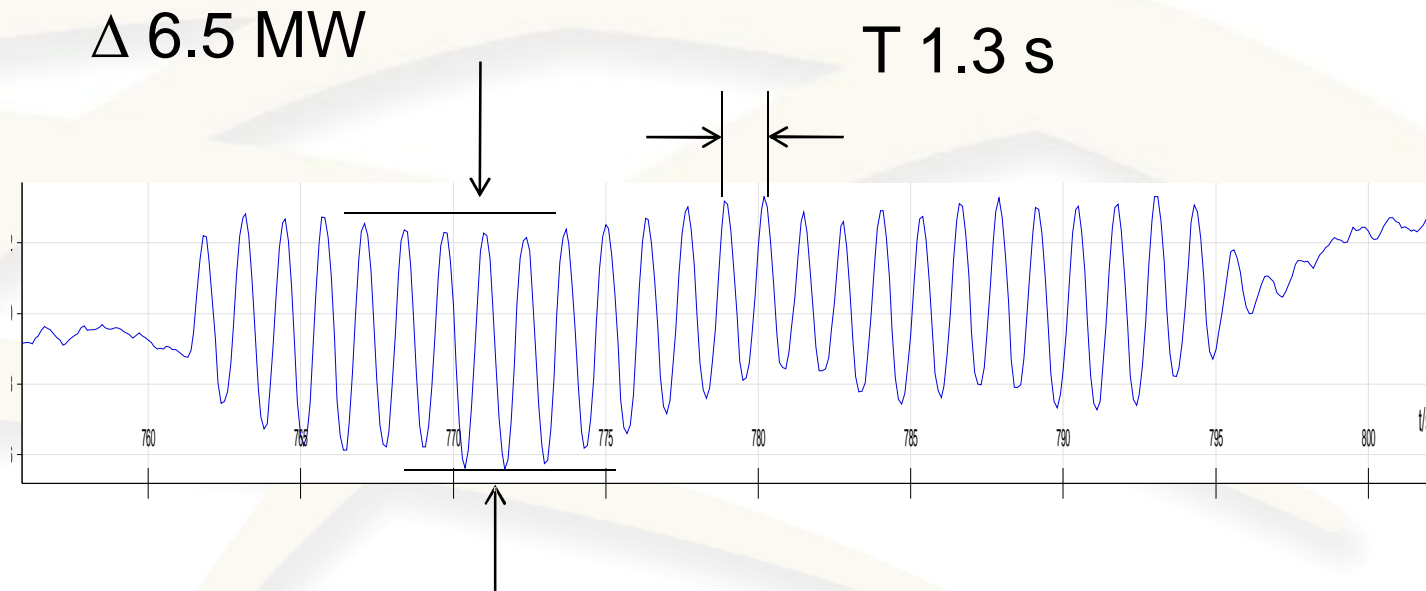


Machine MW Slow Variation (15 s period)



Machine MW (Fast)Variation

(1.3 s period)



Possible Causes

- Different Droop settings on Governors
- Poorly tuned Governors
- Insufficient Damping of system Oscillatory modes
- Governor Deadbands
 - Intentional (settings) / Dynamic
 - Unintentional (valve wear)
- Control system instability

International Experience

- Not unique to Irish System
- Similar Issues have arisen in:
 - Australia
 - Iceland
 - Columbia
 - Denmark



Oscillation Triggers

- Generator trips
- Energising of transformers
- Switching events on Network
- Changing governor modes
- No apparent cause

Next Steps (short term)

- Need to identify Units driving oscillations
- Need to review/understand the various governor operating modes available on each unit
 - Need (Control Centres) to be kept informed of control mode changes
- Some machines may require investigation/testing/ re-tuning of governors and stabilisers
- Need to be made aware of proposed changes to generators

Next Steps (longer term)

- Compliance with Grid Code
- Improved Governor/AVR Models required
- Require timely notification of any proposed changes to governors/AVRs/PSS
 - Information to be made available to Operational Services & Performance
 - Email: Registereddata@EirGrid.com
- Need to evaluate proposed changes to governors
- Need to test and monitor unit performance following any changes to control systems
- Need to have co-ordination of changes (one machine at the time)
- Real time monitoring (via scada to Control Centres) of gov/avr modes

Low Frequency Oscillation – Letter issued to Generators in ROI

Subject: LOW FREQUENCY OSCILLATIONS

Dear Sir / Madam

EirGrid is responsible for the development and planning of the **Transmission System** through legislation, statute and license. In order to achieve this in an efficient and coordinated manner **Users** of the **Transmission System** are obliged through their license to supply necessary information to the **Transmission System Operator (TSO)** as required.

Under the **Grid Code** there are **Governor Control System** requirements of **Generators** which are used to benefit the operation of the **Power System**. These requirements are extracted from EirGrid **Grid Code V3.4** and attached in the Appendix of this letter for reference.

Monitoring (OC10) of the **Transmission System** has shown an increased number of occurrences of low frequency oscillations on the **Power System**. Such oscillations can compromise the reliability and security of the **Transmission System**. These oscillations may be caused by **Generator** alterations to their governor and/or, **Automatic Voltage Regulator (AVR)** and/or **Power System Stabiliser (PSS)** without informing the **TSO** as well as changing **Frequency Response** modes and/or **Frequency Deadbands** without communicating back to the **TSO**.

EirGrid requests that all **Users** identify and inform the **TSO** of all changes made to their **Governor Control System** settings from 1st January 2009. These settings shall include but are not limited by the following; **Governor Droop**, time constants, deadbands, frequency response modes etc. EirGrid would like to highlight to **Users** that these frequency or load related control settings shall not change without agreement with the **TSO** as stated within the **Grid Code** ref: **CC.7.3.1.2**. Further updates and information on this matter will be presented by EirGrid in the upcoming Generation Forum where there will be opportunity to discuss the matter further.

All queries and responses to this can be sent to Registereddata@EirGrid.com with the generators name in the subject line within the next 15 **Business Days**. All received information shall be considered **Registered Data (PC6.5)** for the **Generator Unit** as per the **Grid Code**.

Kind Regards,

Sonya Twohig

Manager of Operational Services and Performance



- SONI will issue a similar letter to generators in Northern Ireland



Grid Code

Key Requirements for Governors

Planning Code

- Supply a prime mover model which completely specifies governor transfer function

Connection Conditions:

- Users shall not change frequency or load related control settings of Unit governors without agreement with the TSO.
- Each Generation Unit must be fitted with a fast acting proportional turbine speed governor to provide Frequency response under normal operating conditions.

Grid Code

Key Requirements for Governors

Operating Code:

- Generation Units when Synchronised shall operate at all times under the control of a Governor Control System
- No time delays other than those necessarily inherent in the design of the Governor Control System shall be introduced
- A Frequency Deadband of no greater than +/- 15mHz may be applied to the operation of the Governor Control System.
- The design, implementation and operation of the Frequency Deadband shall be agreed with the TSO prior to the Commissioning.

Grid Code

Key Requirements for Governors

The Generator may only restrict governor action in such a manner where:

- The action is essential for the safety of personnel and/or to avoid damage to Plant
- In order to secure the reliability of the Generation Unit
- The restriction is agreed between the TSO and the Generator in advance
- The restriction is in accordance with a Dispatch Instruction given by the TSO

If System Frequency falls to below 49.80 Hz each Generator will be required to achieve the required level of response in order to contribute to containing and correcting the low System Frequency.



Summary

- EirGrid/SONI will continue to monitor system oscillations
- Will contact generators if we think a machine is causing or participating in an oscillation
- Require that generators keep us informed of any proposed changes to plant / control systems
- Need to test and monitor unit performance following changes to control systems
- Compliance required with Grid Code
- Questions?