14 Years of Oscillation Management
Lessons Learnt
Landmarks in Oscillation Monitoring


- Control-room continuous monitoring & alarm system
- Mode Phase Analysis added
- First continuous damping monitoring
- C37.118 Interface added

- Constraint relief, UK
- PSS Tuning, CANADA
- Use in System Interconnection, AUS
- Constraint relief, AUS

- Source Location studies, AUS, NZ, Scandinavia, Iceland, UK, S.America, etc...
- Blackout prevented, AUS

- WAMS/EMS Integration

- PSS Commissioning Process adopted, Iceland
- Generator/System Testing Processes, Iceland, S.America

- Model Validation, N.Ireland, Iceland, NZ
Transfer Constraint Relief

- **Area 1** to **Area 2**

### Available Transfer Capacity (MW)
- **Thermal Limit**
- **Transient / Voltage Stability Limits**
- **Model Damping Limit**
- **Model Damping Limit with Margin**

- **Capacity available provided measured damping is acceptable**

- **Applied in Australia & UK**
  - +300MW

**Graph:***
- **Time (sec):** 0 to 500
- **Power Transfer (MW):** -1200 to 0
- Sudden instability in a normally well-damped mode
- Alarm generated in <90 seconds of the onset
- Operators awareness, prompt action despite EMS alarm flood
- Alarm on damping - measured oscillations small, but >300MW at source
- System splitting and blackout avoided
Wide-Area Dynamics Monitoring required for line commissioning

Pre-commissioning
- Baseline of dynamics measured
- System studies

On-line monitoring of damping during tests
- System security
- Conforms with expectation

Review dynamic performance
- Identify degradation
- Model validation
Real-Time Angle & Frequency

- System Integrity
- Islanding
- Angular separation (stress)

Real-Time Damping, Mode Shape

- New poorly damped low frequency modes
- Geographical pattern (mode shape)

Note: Data is for illustration only, not based on a particular event

REAL-TIME STABILITY MONITORING FOR EXPANSION OF THE UCTE SYNCHRONOUS AREA
Wilson D.H., Lubosny Z. (Psymetrix), Lopez-Barba S. (Red Electrica, Spain), APE, Poland, 2009
Power System Stabiliser Tuning Process

Pre-commissioning tests

Immediate monitoring

Short-term response

Long-term review
Diagnosing Dynamics & Control Issues

- Frequency Control Problem
  - Interconnector tripping
  - Load-shed relay tripping
  - Generator stress

- Unknown source of problem
- Several recurrences
- Conventional measurement insufficient to diagnose

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![Frequency Control Diagram](attachment:frequency_control_diagram.png)
- WAMS with PMUs at key nodes

Poorly damped small-signal oscillations - diagnose without waiting for instability

Mode shape reveals common-mode oscillations
- Pattern of mode amplitude in time
  - Correlate changes with SCADA records
  - Choose appropriate time for system tests

Evening peaks in mode amplitude (4 days shown)
Test by changing Control Mode

- Sensitivity to controller parameter
- Normal control mode
- Known safe control mode
Iceland: Oscillation problem found by correlating EMS data with damping
- Approach used in Australia, Scandinavia, South America, UK
- Sensitivity important for defining response
Windfarm-System Interaction

- Blade-passing frequency seen strongly in windfarm power
  - Video & blade angle recognition
  - Statistical analysis
- Measurement-based evidence of blade angle coherency
- Effect replicated in detailed model
**Practical Considerations**

**Phasor Measurement Units**
- Address different dynamic performance
- Continuous vs on-demand PMUs

**Phasor Data Concentrator**
- Substation data buffering
- System tests can be several hours
- Careful filtering before downsampling

**Oscillation Applications**
- Real-time
  - Robust against lost data
  - Fast response
  - Clear geographic pattern
  - Well set alarms
- Off-line
  - Slower response
  - Accurate & stable

**Data Storage**
- Continuous dynamics data storage (e.g. 1 year)
- Triggered longer-term storage
- Link SCADA & dynamics archives

**Client Applications**

**EMS Integration**

**C37.118 PMU/PDC Data Stream**

**WAMS/EMS Exchange**
Key Lessons Learnt

- **CONTROL ROOM**
  - Key part of situational awareness
  - Guidance / practical knowledge vital

- **PLANT PERFORMANCE**
  - Test process is effective & secure
  - Improve understanding of plant/system interaction

- **PLANNING**
  - Valuable diagnostic tool esp. where model imperfect
  - Understand the risks, facilitate control-room response

*Now incorporated in Operational, Planning & Test Procedures*

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