A Fault Monitoring and WAMS Installation on the GCC Interconnection Project

Based on a joint paper presented at the 4th General Conference of Arab Union of Electricity and Exhibition January 2013 by GCCIA, Qualitrol and Psymetrix

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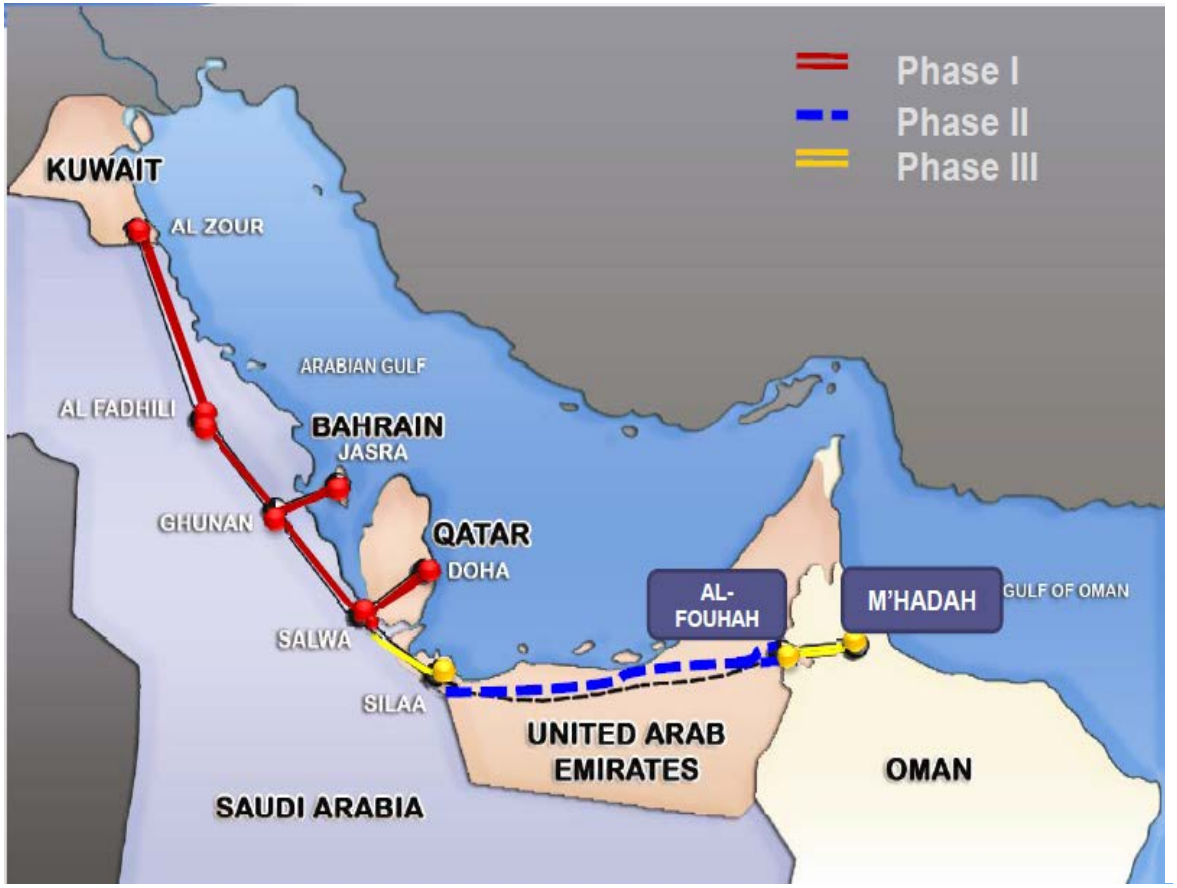
The GCC Interconnection Project



Phase 1 - the interconnection of Kuwait, Saudi Arabia, Bahrain and Qatar forming the GCC North Grid

Phase II - the interconnection of the independent systems in the United Arab Emirates (UAE) and Oman forming the GCC South Grid

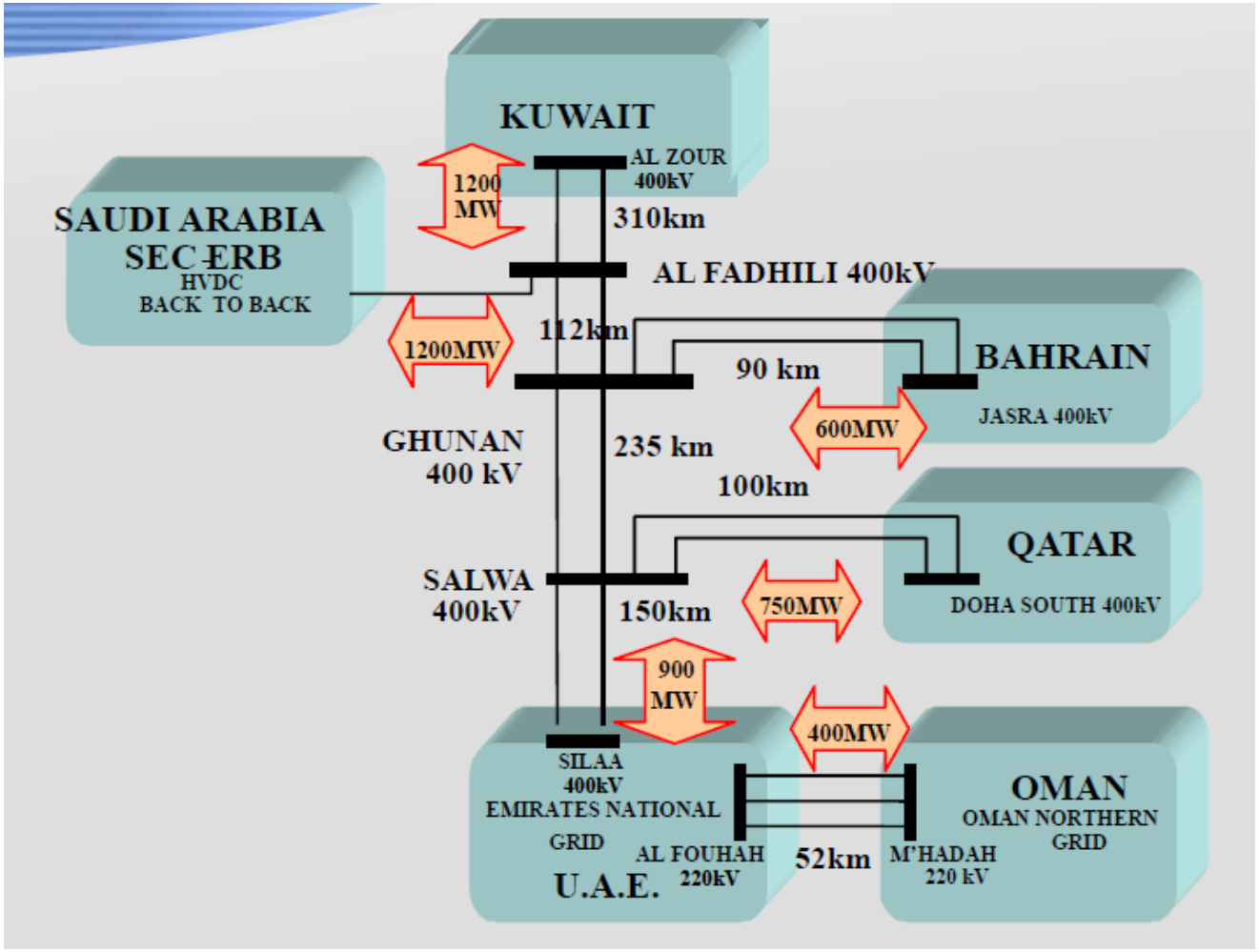
Phase III - the interconnection of the GCC North and South Grids

Connects six countries with 400 and 220KV links

The GCC Interconnection Project

- 50Hz 400 KV Interconnection
- Saudi Arabia 60Hz, connected by back-to-back HVDC converter at Al Fadhili.
- Last section in the South between UAE and Oman is at 22KV
- Long lines subject to oscillations – approximately 1,000Km end to end

Objectives



- Ensure Power System stability.
- Avoid instability factors.

Planned Power Interchanges on the Link

Initial Operational Studies

✓Stability analysis identified different oscillation modes in particular an inter-area mode between North and South.

- ❑The study recommends installation or activation of PSS.
- ❑The target of 5% damping has been achieved, however, margin remains limited and justifies continue installation of PSS for large units without PSS.

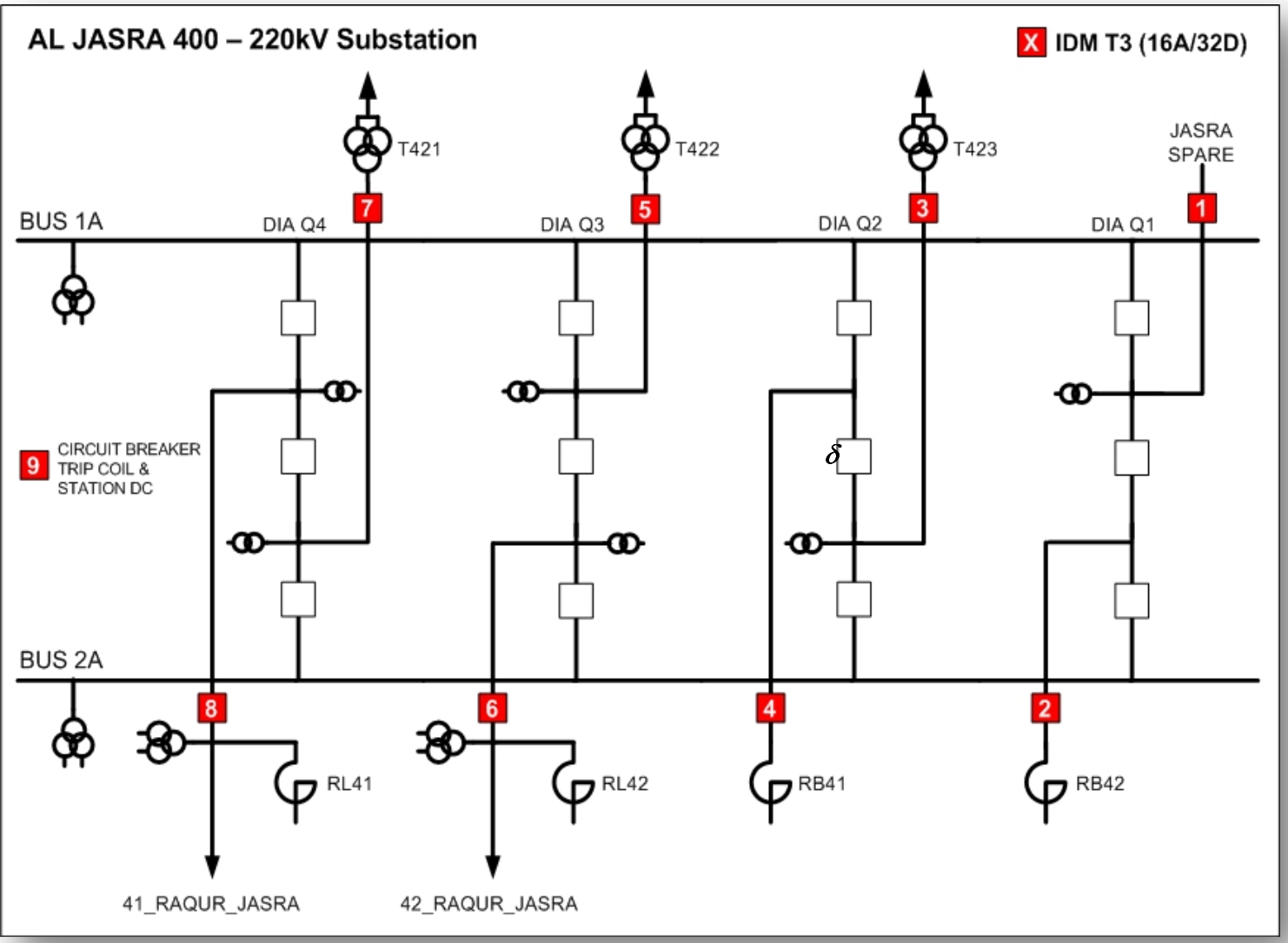
Initial Operational Studies

✓The nominal power rating of the equipments of the interconnection (lines, cables and transformers) shows the maximum power transfer capacities are not constrained by stability limits.

✓The simulations of system faults have shown that the GCC system is stable except for few localized cases showing possibility of voltage collapse

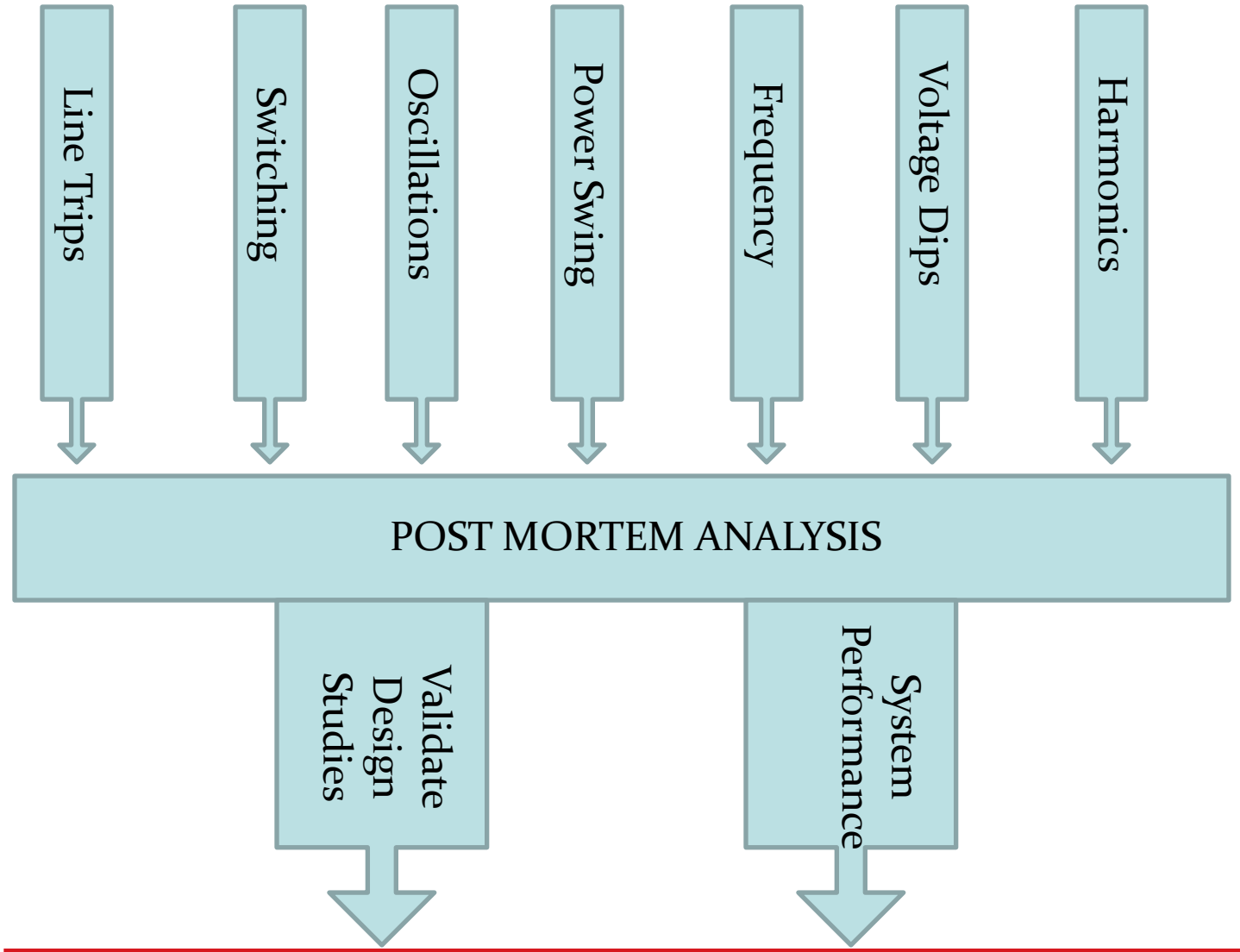
The study recommends the Installation of Recording devices like WAMS, FMS to monitor the system behavior and analyze system parameters to allow build precise model.

FMS/ WAMS in all substations in the Northern Grid



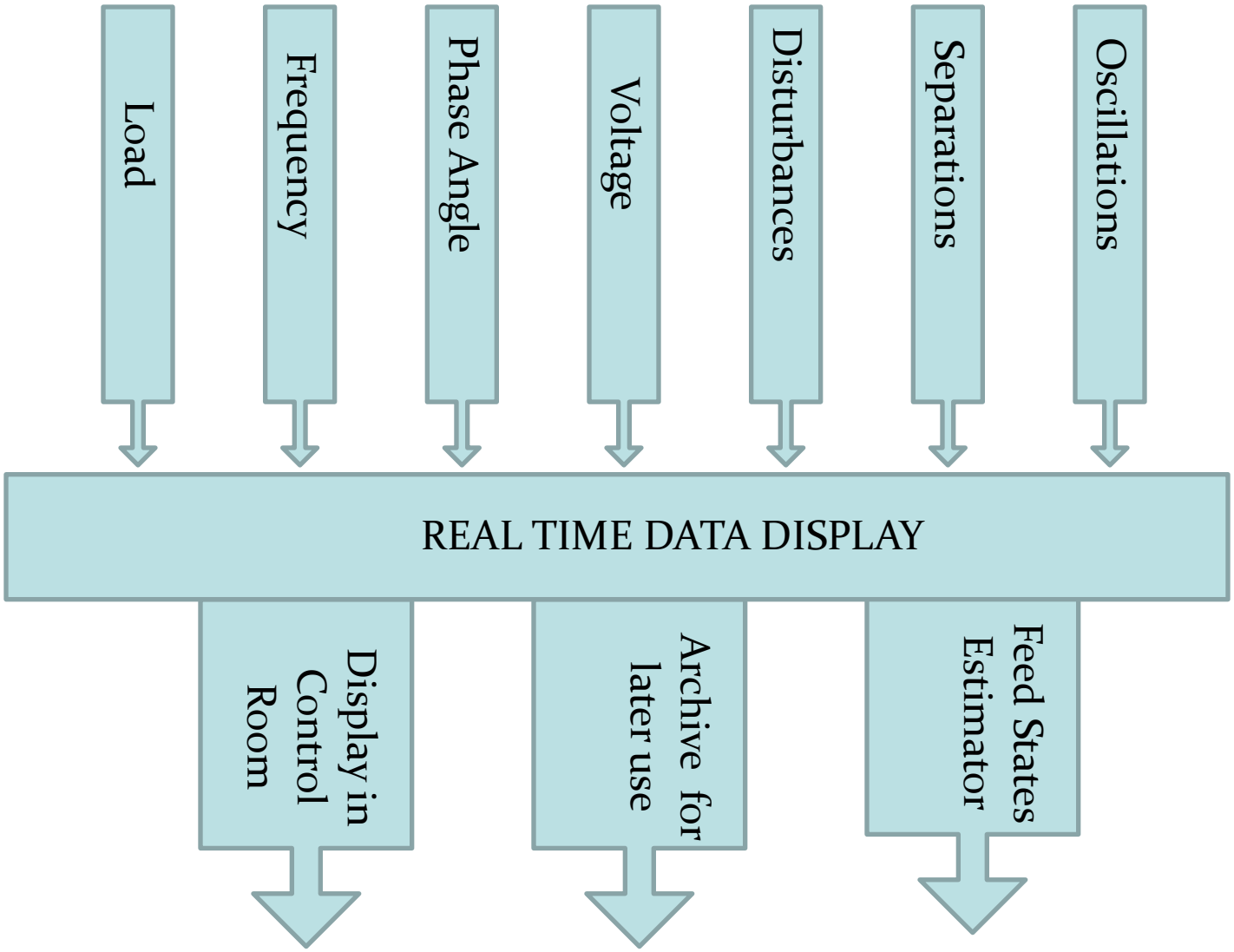
- Signals monitored: voltages, currents, Substation DC supply, CB Trip coils, Protection, auxiliaries

The FMS will provide Post Mortem Analysis



- Fault Recording, Distance to Fault , Slow Scan recording, Harmonic logging, Phasor Measurements
- All recorders are time synchronised to GPS source to an accuracy of 5 micro sec with ethernet connection.

The WAMS will provide Real Time Display & Archive



- In order to improve the observeability of the inter-area modes and **validate damping** improvements;
- comparison of active power flow, angular deviation and frequency seen between very far located units
- GPS time synchronized

FMS WAMS Installed at 7 substations

3 phase volts and currents, CB trip coils and digital inputs

PMU – streamed phasor data at 50Hz frame rate

DFR data – triggered records at 6.4KHz sampling

SLOW SCAN data – rms mag, freq, harmonics, power at 50Hz sampling

WAMS

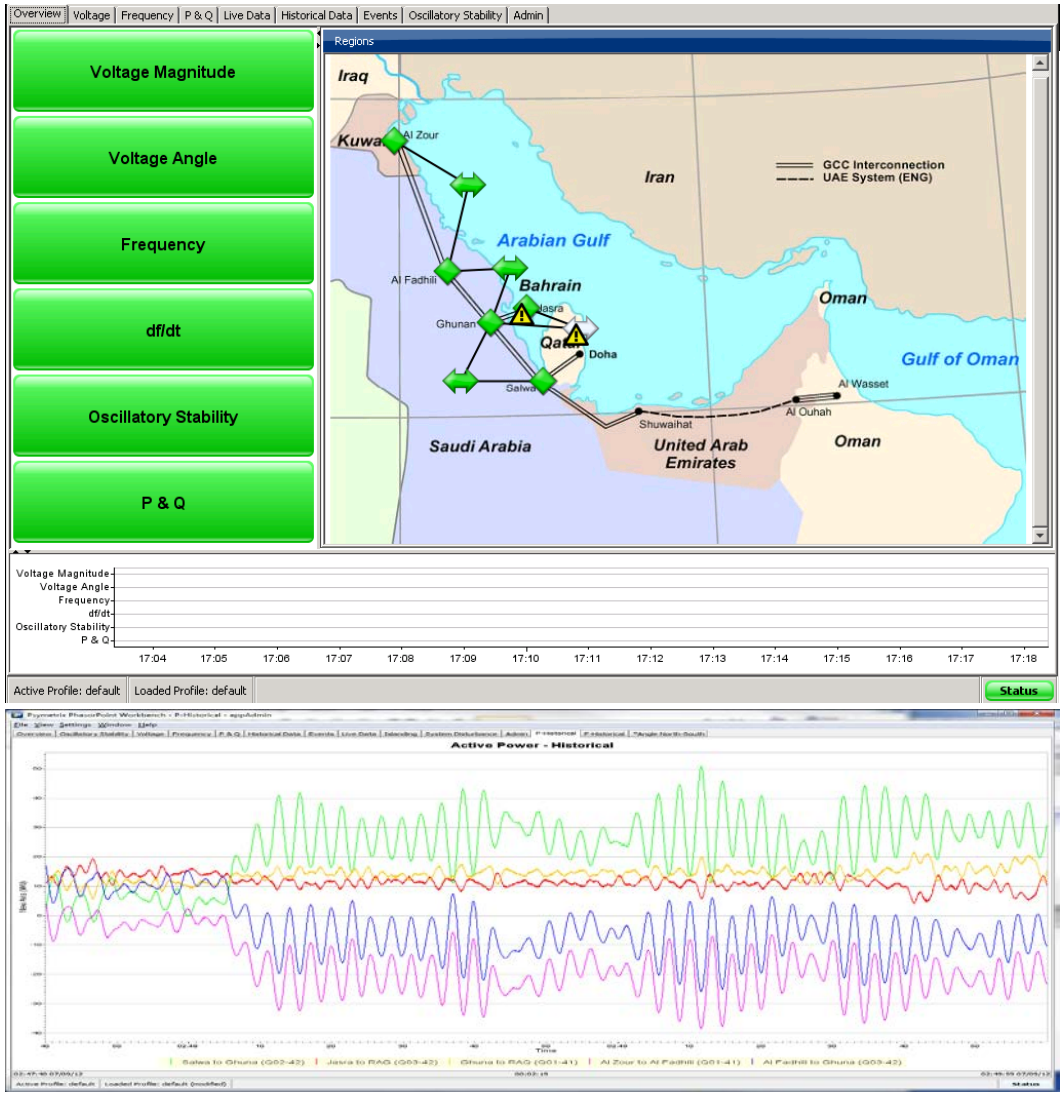
PDC – phasor data concentrator and PhasorPoint software

FMS

CONTROL ROOM

Replay Plus – DFR Master Station software

WAMS Real Time Overview Display



Event Type

Tabs on Left show GREEN/YELLOW/RED alarm status for different events like voltage, oscillations etc. WHAT event is happening

Location

Icons on the map change colour GREEN/YELLOW/RED WHERE happening.

Time

15 minute event history showing WHEN events took

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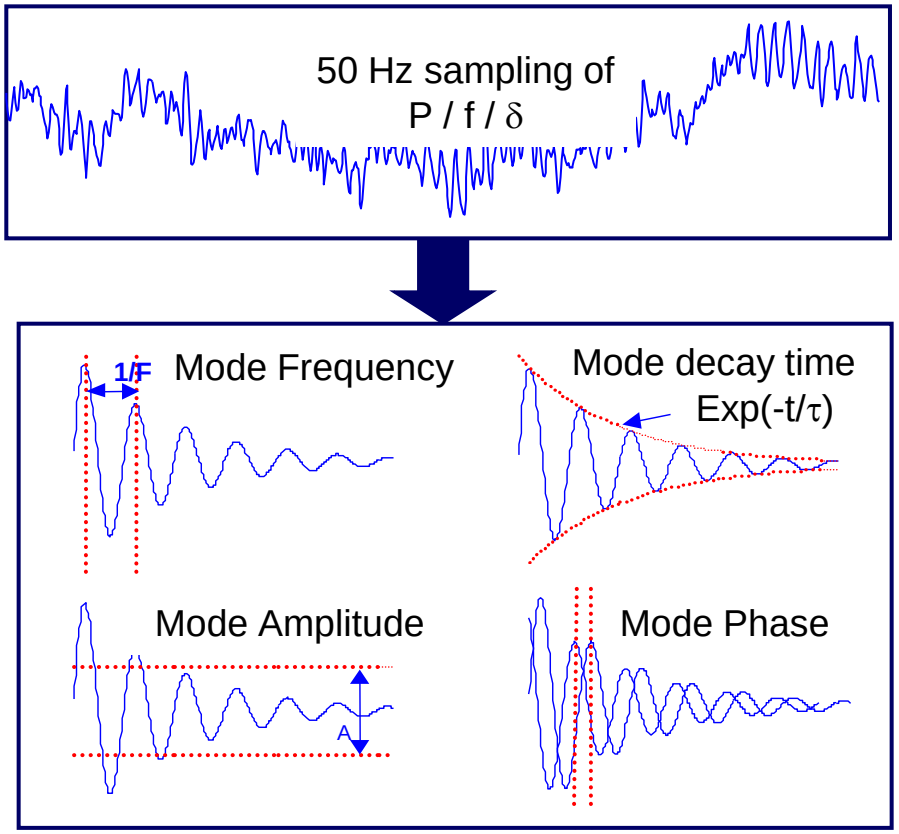
Oscillatory Stability



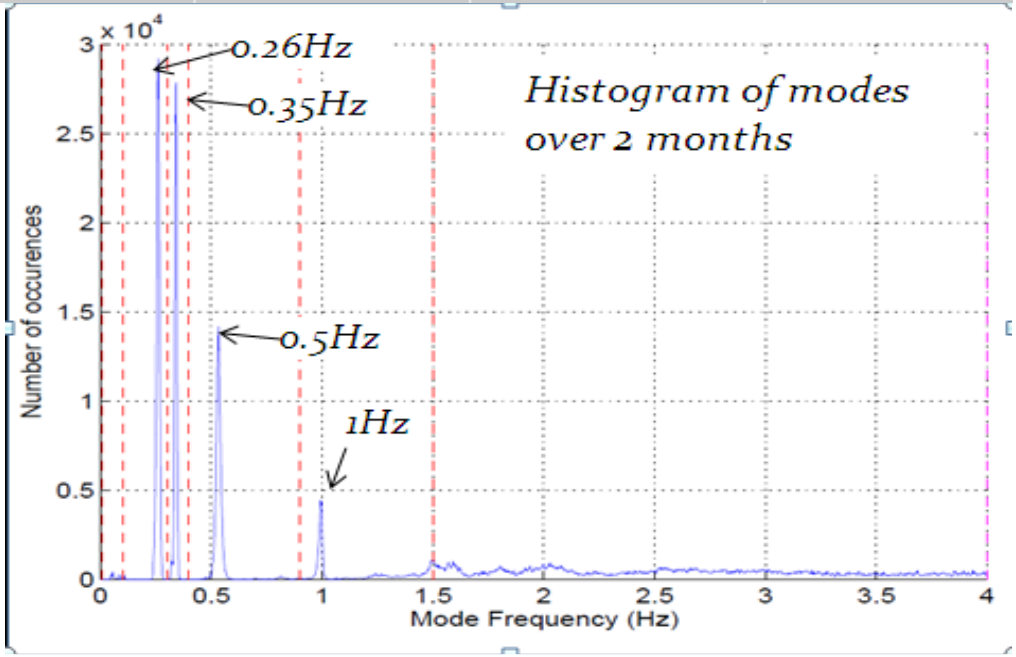
allows extraction of low frequency dominant modes of oscillation (up to seven different modes between 0.03Hz – 5Hz)

- Four attributes of mode are – Damping (% or seconds), Amplitude , Frequency (Hz), Phase (degrees)

Damping and Amplitude are mode stability indicators. Mode must be damped

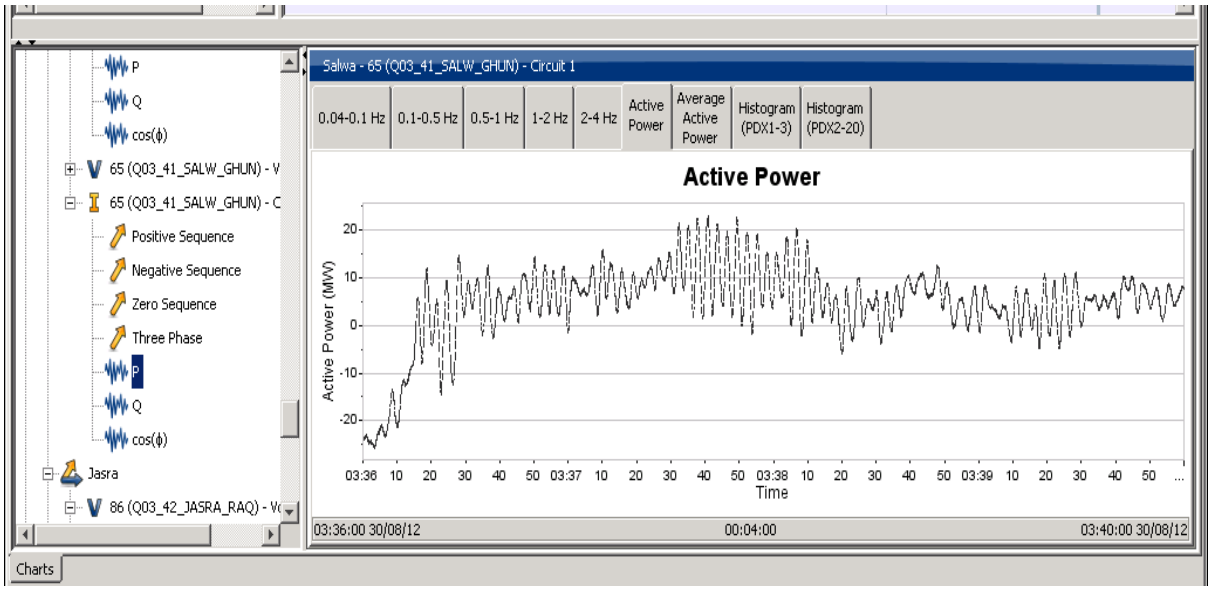
WAMS – System Oscillations

Mode	Average / Peak Decay Time	Average / Peak Amplitude	Comment
0.25 Hz	6 sec / 24 sec	2 MW / 30 MW	Interarea mode Moderate risk
0.35 Hz	8 sec / 35 sec	2 MW / 35 MW	Interarea mode Moderate risk
0.5,1Hz etc.	Well damped	Small	Low risk



- Summary of oscillations detected over a 2 month period and their possible effect on stability
- Inter-area mode at 0.26Hz is observed. The oscillations are in phase.

WAMS Example – System Oscillations

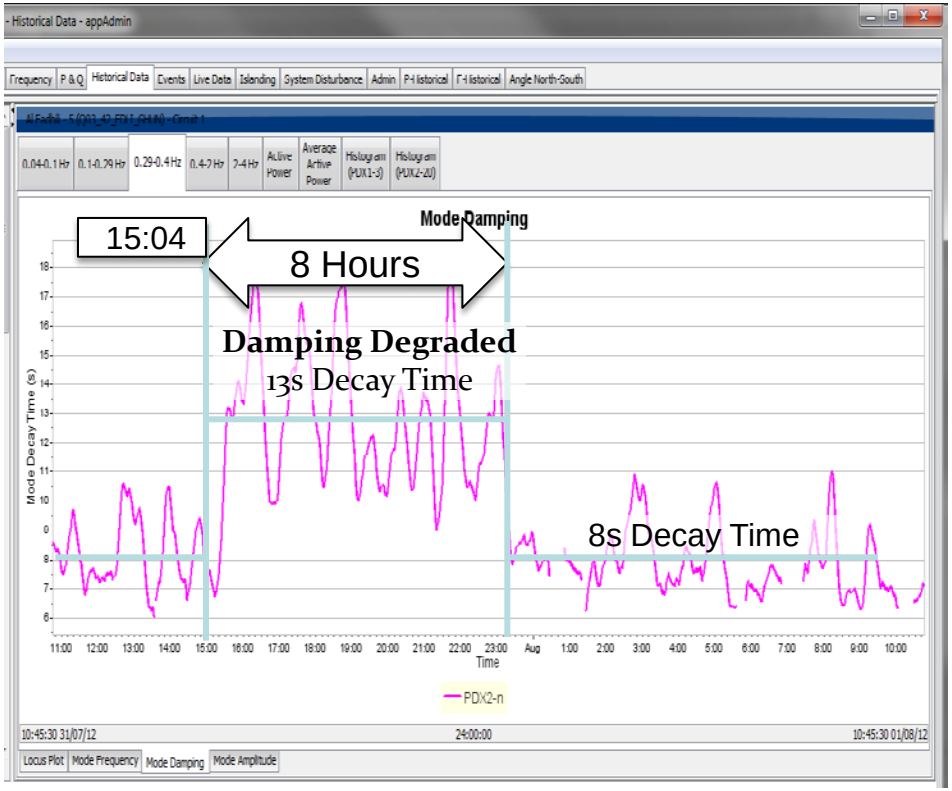


Example of a lightly damped 0.26Hz mode oscillation

Specific actions to reduce oscillations will involve:

- Identifying generators contributing to oscillation and redispatching them
- Design and/or tune Power System Stabilizers on these generators
- Strengthening the interconnection between neighbouring countries

Example of 0.35Hz Oscillation Behaviour



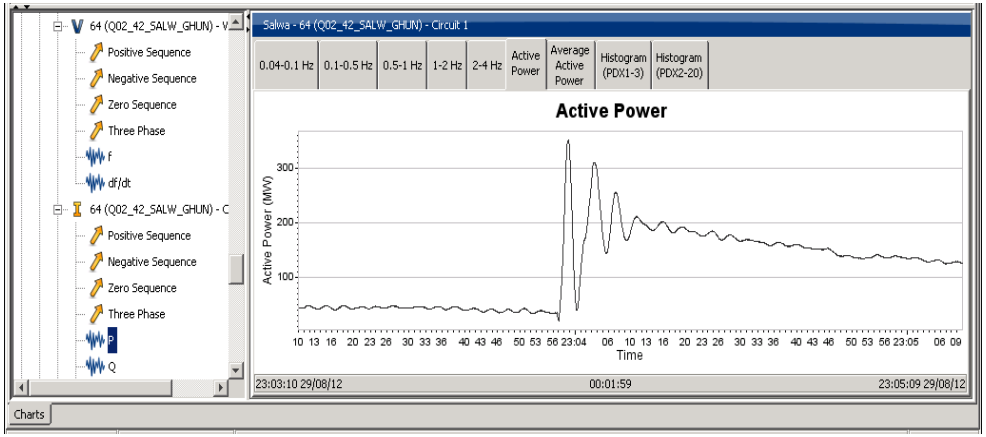
- ❑All interarea modes are sensitive to operating mode;
- ❑Dispatch & topology affect damping.

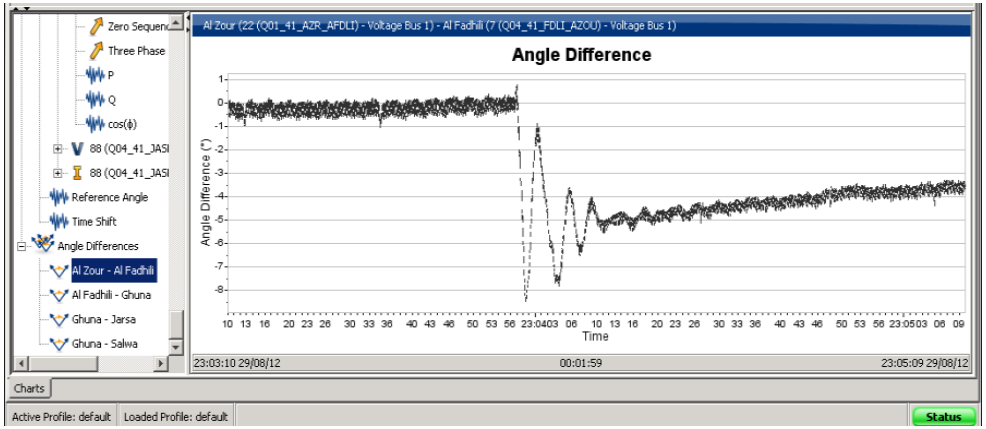
Example shows damping degraded for 8 hours

→ *Change in Operating Point affects stability*

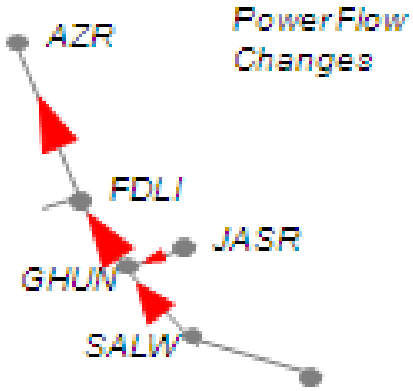
→ *Observed patterns useful to determine operational response*

WAMS Example – Loss of Generation in the North – power, angle





- Increase in active power at Salwa flowing North
- Change in phase angle between Al Zour and AL Fadhili
- Damped transient response with a dominant mode of 0.26Hz



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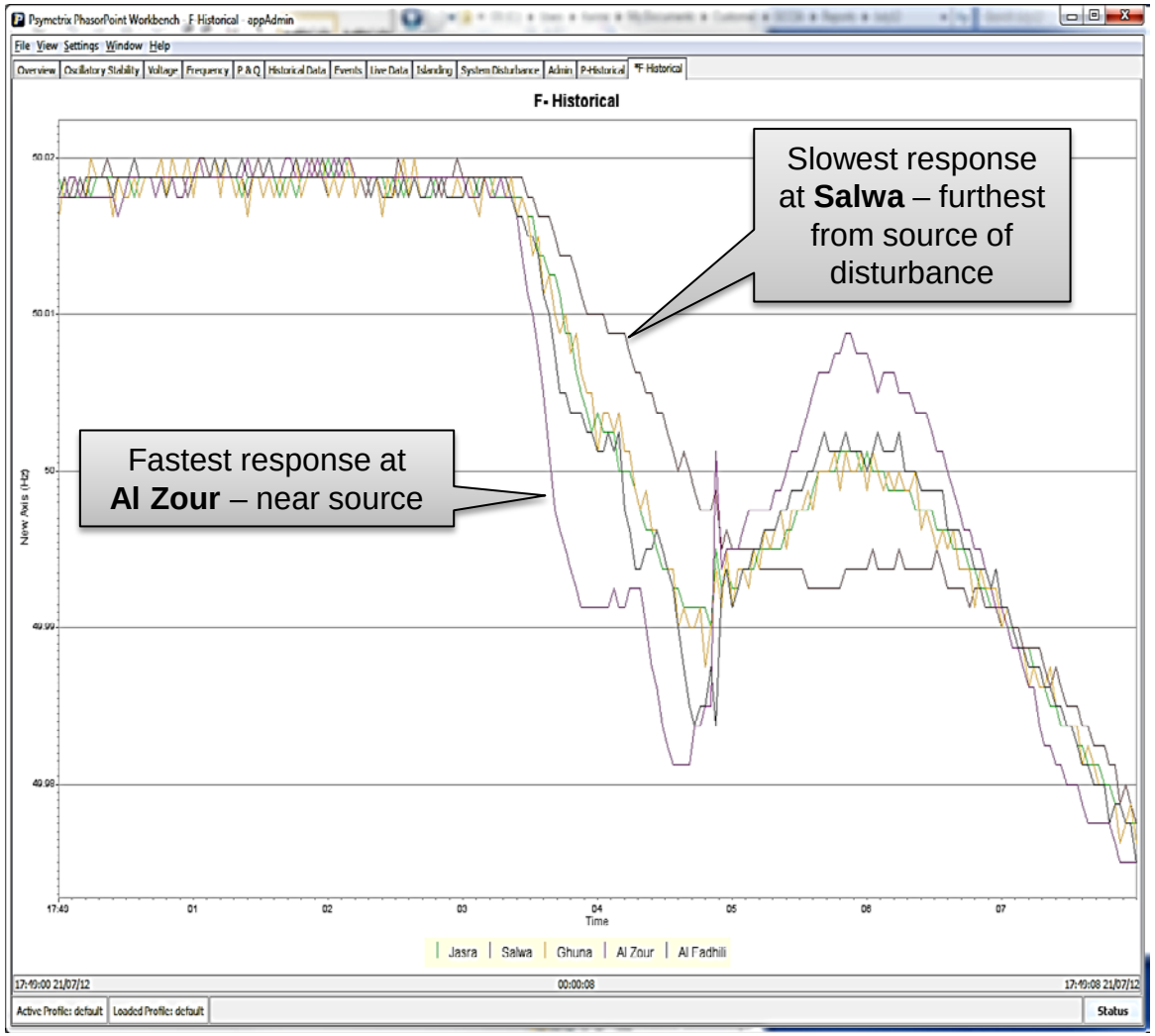
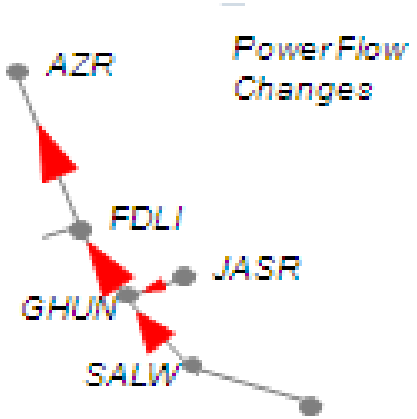
WAMS Example – Loss of Generation in the North - freq



Frequency (and angle) records show earliest movement close to generation loss.

Frequency falls to 49.97Hz in just over 4 seconds



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Summary

The FMS / WAMS were commissioned in 2012 and early results have already enhanced the understanding of the transient response of the GCC Interconnection.

The interconnection spans around 1000km from north to south. Early Operational Studies of Phase I and Phase III predicted a tendency for the system to experience low frequency inter-area oscillations. **WAMS** provides a means to analyse the performance of the whole interconnection such that it can be managed in such a way that all oscillations including the inter-area modes remain damped.

FMS transient and disturbance data will improve the understanding of the transient response, highlight potential weaknesses in the assets that can be corrected and thereby enhance the system security.

Q & A

Thank you for your time