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Study Committee B5

Protection & Automation

10120_2022

Wide Area Protection Scheme for Prevention of Islanding of South Australia

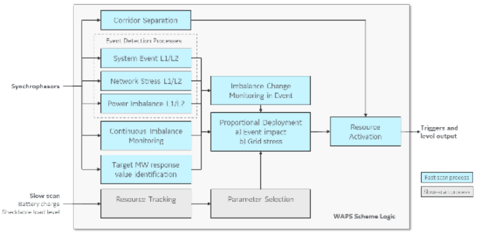
Douglas WILSON[1], Seán NORRIS[1], Devinda PERERA[2], Yang LIU[2], Leonardo TORELLI[3]

[1]GE Digital, UK; [2]ElectraNet, Australia; [3]CSE Uniserve, Australia

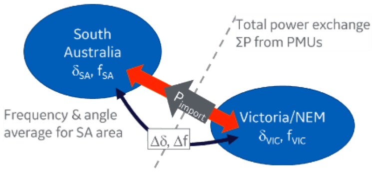
Motivation

- South Australia has high penetration of renewables and inertia varies greatly
- Loss of synchronism to wider network (NEM) can result from many high impact / low probability events
- Conventional SIPS cannot address the wide range of possible sequences.
- Synchrophasor based WAPS is a generalized approach to apply regional fast balancing response to maintain synchronism.
- Novel approach successfully trialed, now being deployed.

WAPS Control Scheme



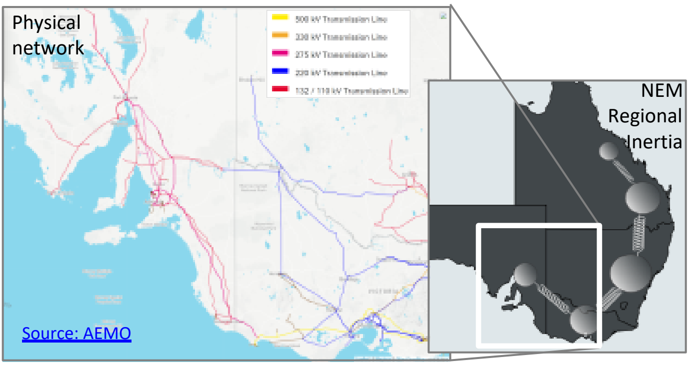
Disturbance Detection



- **Network Stress:** Angle difference ($\Delta\delta$), frequency difference (Δf), projected angle difference ($\Delta\delta + k\Delta f$). Measure of stability.
- **Power Imbalance:** Level & change of power balance in SA ($-P_{imbal} + H_{SA}ROCOF_{SA}$). Measure of region power balance change.
- **System Event:** F_{SA} & $ROCOF_{SA}$ with external NEM event blocking. Fast detection in low inertia state.

Disturbance Response

- Level **L1** BESS – slower but more flexible than L2
  Level **L2** Load shed – faster, applied to critical events
- **Response:** Power Imbalance ($-P_{imbal} + H_{SA}ROCOF_{SA}$) minus Power Target. Proportionate to event and adapt to network state.
- **Deployment:** Dispatch to L1 & L2 resource blocks



Source: AEMO

http://www.cigre.org

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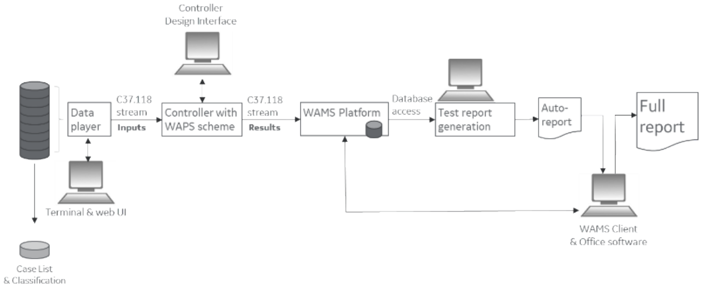
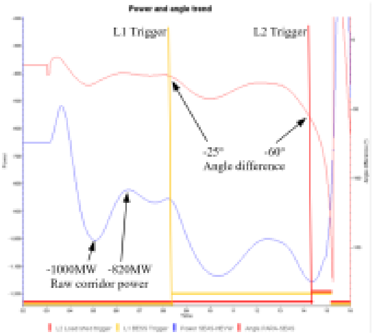
Experimental setup & results



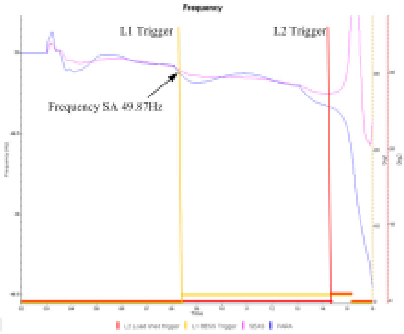
Example: large generator 3 units trip at 5s intervals. L1 BESS triggers just after the Unit 2 trip; L2 load shed 0.6s before instability

- 279 Complex multi-event simulations used as case library to test and tune scheme
- Open-loop testing for trigger accuracy
- Subset of closed loop tests for response to control
  (A) manually inserted response (B) Control scheme in PSCAD control loop
- Network Stress most general for severe events, as the first criterion to trigger L2 in 66 cases, of which it is the only L2 trigger in 57 cases.
- System Event is an early trigger (lowest latency) for 39 cases at L1, all of which were followed by another.
- Power imbalance also an early trigger in 84 L1 cases
- **All tests met required performance**



Category	Target L1	Target L2	# Tests
Stable Credible	R	R	**70 25%**
Stable Non Credible	M	R	**101 36%**
Marginally Stable Non Credible	T	M	**27 10%**
Marginally Unstable Non Credible	T	T	**12 4.3%**
Unstable Non Credible	T	T	**62 22%**
Other	Case-by-case		**7 2.5%**

R: Restrain
M: May trigger
T: Trigger



Statistics for FIRST/ONLY criterion to trigger at L1 or L2 level

Target Response		Power Imbalance		Network Stress		System Event	
L1	L2	L1	L2	L1	L2	L1	L2
Restrain	Restrain	0 0	0 0	0 0	0 0	0 0	0 0
May trigger	Restrain	20 19	0 0	2 2	0 0	4 0	0 0
Trigger	May trigger	20 13	2 2	2 1	6 6	6 0	1 0
Trigger	Trigger	44 0	10 0	5 1	60 51	29 0	6 0
TOTAL FIRST (ONLY) CRITERION		**84 (32)**	**12 (2)**	**9 (4)**	**66 (57)**	**39 (0)**	**7 (0)**

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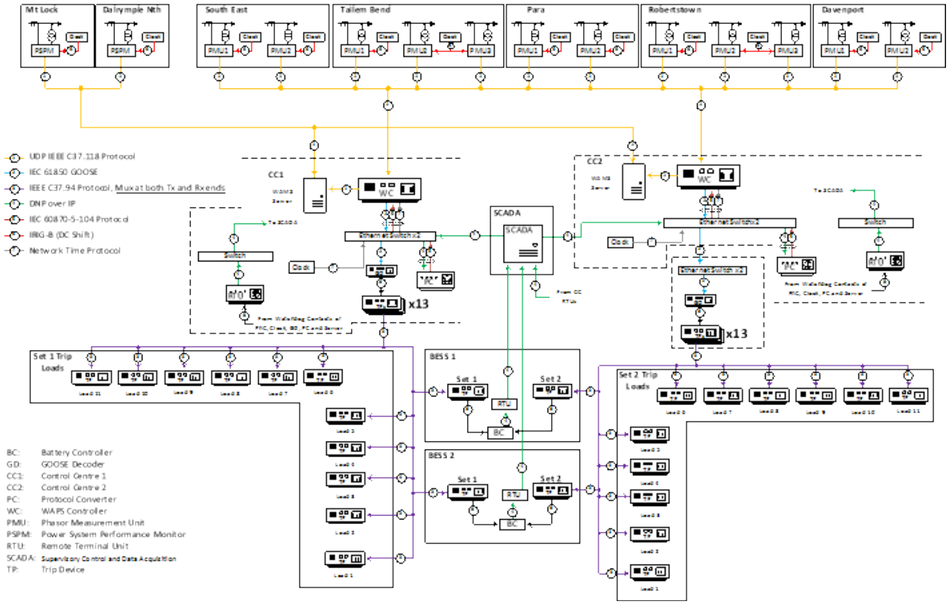
System Implementation



Conclusions

- WAPS scheme responds appropriately to all the multiple event sequences of disturbances tested – addresses uncertainties with complex scenarios
- Synchrophasors enable fast-acting control sensitive to the dynamic state of the system – the movement of the power system determines the need for response and volume
- Inherently adapts to changing conditions e.g. renewable generation share, system loading & network strength
- Novel approach to triggering captures 3 distinct indicators of response: network stress, power deficit, frequency/ROCOF
- Novel proportionate response method applied for identifying power imbalance rapidly using P, H and ROCOF
- Further developments include embedding the control scheme into dynamic system model, directly as implemented in live system
- Adaptable approach to changes to topology, including strengthening of the interconnection to NEM

Further reading

[1] Hong Q., *et al.*: "Design and Validation of a Wide Area Monitoring and Control System for Fast Frequency Response", IEEE trans Smart Grid, 2020

[2] EC Horizon 2020 project MIGRATE "D2.3 Lessons Learned from Monitoring & Forecasting KPIs on Impact of PE penetration, https://www.h2020-migrate.eu/ 25/09/18

[4] D. Wilson, B. Heimisson, R. Gudmansson, H-L. Cheng "Experience of fast-acting wide area control with geothermal governing to manage separation and island running ", Cigre Paris Session, Aug 2020

[5] D. Wilson, *et al*, "Icelandic Operational Experience of Synchrophasor-based Fast Frequency Response and Islanding Defence", Cigre Paris, 2018