Study Committee C4

PS3 Challenges and advances in power system dynamics

10205_2022

Real Time Simulation & Demonstration of Black Start on Transmission Networks using Embedded Generators

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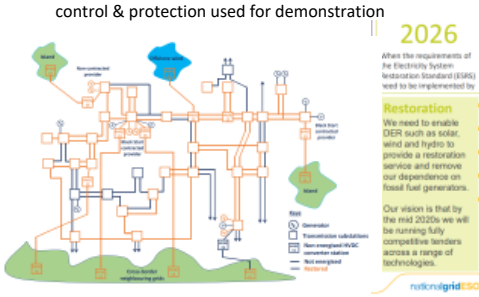
Motivation

- In GB- no history of using or specifying distributed generation (synchronous & non-synchronous) to deliver "Black Start" system restoration.
- National HVDC centre using CHIL real time analysis, de-risking Black start trial demonstration and new control & protection used for demonstration



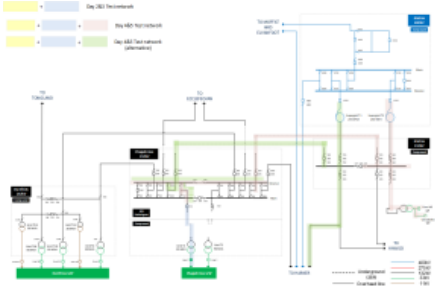
Today ***Tomorrow***

Method/Approach

- System restoration and the concept of using an "anchor generator" is well understood, and relatively straightforward when generator is designed for that purpose. Here no such specified generation exists.
- Technique to use collective "bottom-up" restoration resources within distribution system requires specific validation.

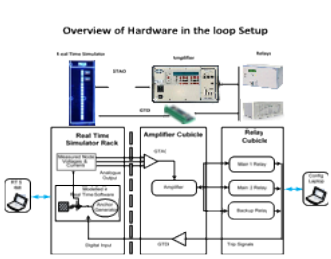
Objects of investigation

- Distribution system in SW Scotland
- Synchronous anchor generator example
- Extent of and stability of restoration possible
- Identifying and de-risking anchor generator capability
- Understanding complementary control and protections necessary



Experimental setup & test results

- Realtime- CHIL, now including distributed controller
- Energisation, load blocks, synchronization, optimization of resources



Discussion

- Designed energisation steps and tested against range of test sensitivities
- Granular RSCAD model of anchor generator, its control and protection developed as Black Start performance not specified & cannot be assumed
- Results (overleaf) successful, once a local resitive load is introduced to support starting power island.

Conclusion

- Black Start from resources not specified to support restoration is possible; but needs cautiously approach modelled in great detail in real time EMT
- A local resistive load, and point on wave limitations of energization angle necessary to support.
- A distributed controller reserving capabilities of anchor generator, with other resources offsetting MW in power island is essential to maximise restoration capabilities.

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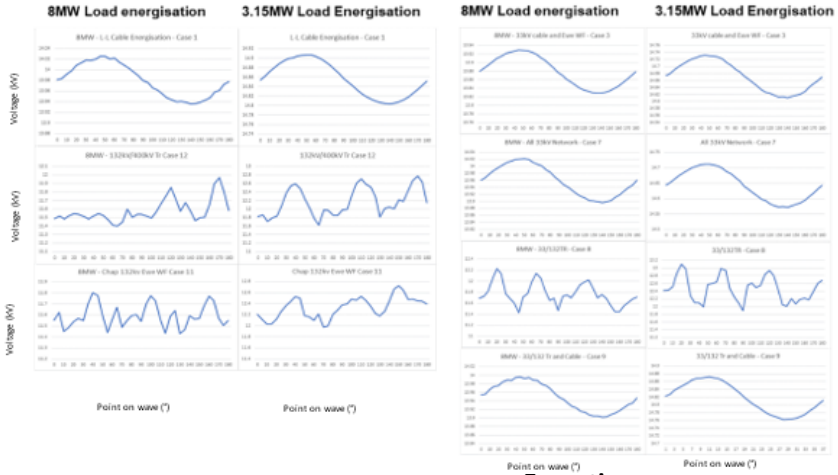
Modeling & setup considerations

- I/O interfaces, amplifier integration with protection
- Test & data sheets vs detailed model of generation, undervoltage protections, overcurrent protections
- Interfacing timesteps of models
- Models of load
- Time sequencing of simulations

Key analysis considerations

- No -load operation.
- Energisation duty
- Voltage regulation
- Load uncertainty
- Sensitivities of assumptions, time sequencing, linking and adapting outcomes to intended trials.

Illustrative Energisation results



Planning

- Assess available options
- Identify control options
- Link simulation and trial to broader conclusions relating to black start services.

Execution

- Describe restoration strategy in detail
- Define range of scenarios- load variability, EMT analysis assumptions (remenant flux of transformers, Point on wave etc.
- Understand limits of anchor generation in co-ordination with other resources.