

Study Committee C4

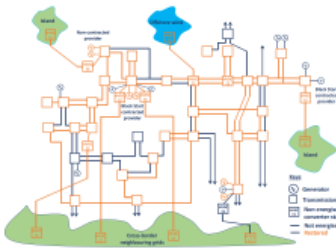
PS3 Challenges and advances in power system dynamics
10205_2022

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



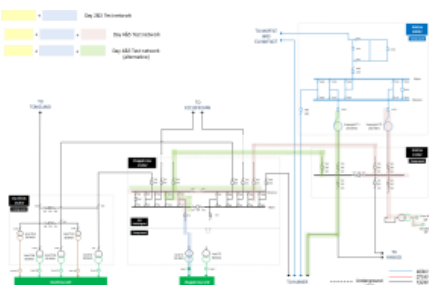
2026
When the requirements of the Electricity System Restoration Standard (ESRS) need to be implemented by 2026
Restoration
We need to enable DER such as solar, wind and hydro to provide a restoration service and remove our dependence on fossil fuel generators.
Our vision is that by the mid 2020s we will be running fully competitive tenders across a range of technologies.
rnlscgrid.co

Today 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.

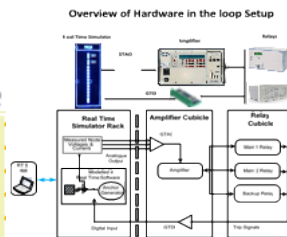
Objects of investigation

- 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 resistive load is introduced to support starting power island.

Step	Element/Load	Chilgen/Load	Breaker Closed	Close Interval	Open Interval	Open Delay
Normal Grid 110kV cables						
1	Cable to Chap 110V	N/A	11		0:00:00	N/A
New 110V D/SF						
2	Bus 110V D/SF	11:01	11,12,13,12		0:00:00	N/A
3	Bus 110V D/SF	N/A	11,12,13,12,11,12		0:00:00	N/A
Protective relays						
4	ADNAP Primary	11:01	14		0:00:00	A,80%, B,0%, C,80%
5	Midge 110V 3 Phase	11:01	11,13		0:00:00	A,80%, B,0%, C,80%
6	Lockbar	11:01,13	13		0:00:00	A,80%, B,0%, C,80%
110V Network						
7	All generators + Storage	N/A	11,12,13,12,11,12,11,12		0:00:00	A,80%, B,0%, C,80%
8	Grid Tn (resistive)	11:01	09415		0:00:00	A,80%, B,0%, C,80%
9	Grid Tn (resistive)	N/A	11,12,09415		0:00:00	A,80%, B,0%, C,80%
Chap 110V 110V						
10	Chap 110V 110V	11:01, 09415	710,207	110V 110V	0:00:00	N/A
Chap 110V 110V						
11	Genes 110V 110V	11:01, 09415	881,09415		0:00:00	A,80%, B,0%, C,80%
Genes 110V 110V						
12	Genes 110V 110V	11:01, 09415	881,09415		0:00:00	A,80%, B,0%, C,80%

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

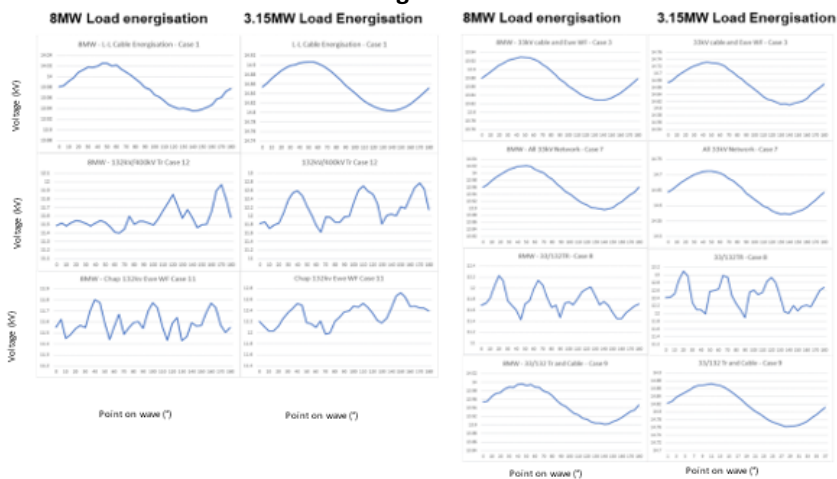
Modeling & setup considerations

- 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 (remnant flux of transformers, Point on wave etc.
- Understand limits of anchor generation in co-ordination with other resources.

