

Study Committee C2

Power System Operation and Control

Paper ID 10200_2022

INERTIA MEASUREMENT IN THE GB POWER SYSTEM USED FOR OPERATIONS AND PLANNING IMPROVEMENTS

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Context

Introduction of inverter-connected Renewable Energy Sources lowers system inertia.



System operation becomes more challenging due to volatile frequency and RoCoF.



Increased visibility of system inertia is needed to safely and efficiently operate low-inertia systems.



Measuring inertia allows the optimisation of inertia dispatch and frequency response procurement.



World's first Inertia Measurement methodology



A Modulator¹ injects a minute and controlled periodic power signal.

The power grid responds with imperceptible frequency movements.

XMUs measure frequency and RoCoF across the whole grid.

GridMetric® cloud platform computes the inertia measurement using the Swing Equation and advanced signal processing.

Inertia data is available from any internet connected device. The measurements can be streamed via an API to the Control Center to drive actions.

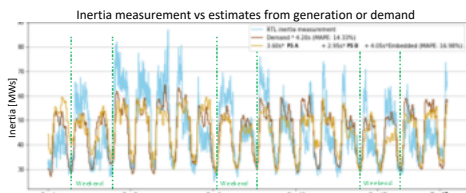
¹Modulator: an asset such as a battery, ultracapacitor or load bank capable of generating a power signal

²XMU: eXtensible Measurement Unit, Reactive Technologies' GPS synchronized accurate measurement unit.

Inertia Measurement - islanded grid

- 20 consecutive days of inertia measurement in an islanded grid off the coast of Scotland (≈20MW capacity)
- GridMetric system, 15kW peak-to-peak modulation (from a load-bank) and 5 XMUs.

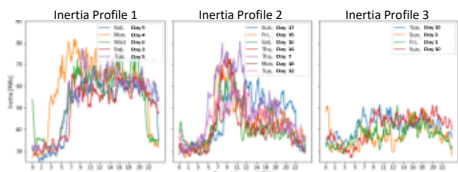
The profile mostly followed that of demand or generation, but in several occasions inertia was higher or lower than the simple estimates based on their profiles.



Three inertia profiles were found:

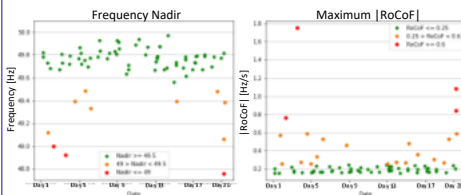
- High inertia throughout the day
- High inertia in the morning, lower in the afternoon
- Low inertia throughout the day

Note that the day of the week or demand level alone are not sufficient differentiator between classes.



Secured Loss calculation - islanded grid

- 73 significant frequency or RoCoF events found.
- Events with RoCoF higher than 0.6 Hz/s were associated with Nadirs of 49 Hz or lower and UFLS action.
- 0.6 Hz/s was chosen as RoCoF limit for the secured loss calculation (i.e. Determining the largest generator loss that the system can sustain without triggering Underfrequency Load Shedding).



- Inertia measurement was utilised to calculate the secured loss in real time and for the events recorded.
- It was found that only half of the time the largest generator could be run at 1 MW and never at 2 MW.

	Nadir [Hz]	RoCoF [Hz/s]	Inertia [MW]	Event size [MW]	Secured loss [MW]	Exceedance
Day 2 07:35	49.00	0.76	65.52	2.00	1.57	127 %
Day 3 13:05	48.92	1.75	35.06	2.46	0.84	293 %
Day 20 05:30	48.76	1.08	40.16	1.74	0.96	181 %

Such incidents can be avoided by limiting the largest loss, increasing inertia and procuring more frequency response. These actions are expensive and hinder the green transition when taken unnecessarily. Measuring system inertia removes the guessing game, enabling safe and economically efficient system operation.

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continued

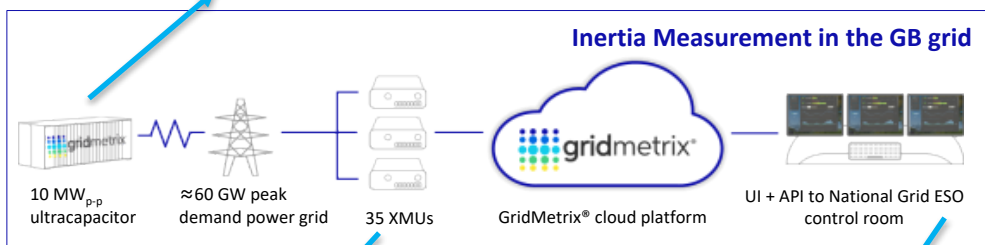
**World's largest
grid-scale ultracapacitor**

Antenna for communications Inverters 11kV Transformer



Container houses ultracapacitor cells and modules, control system, cooling system, fire detection and suppression

Output required: 10MW ptp continuous sine wave or square wave signal every 2 – 10 seconds



Conclusions

- The GridMetric Inertia Measurement was applied to a small islanded power system. Over the 20-day project, several contingency events were recorded alongside real-time inertia data. This data allowed the computation of the Secured Loss metrics to aid safer system operation and provided data to update and retune the system's simulation models.
- The world's largest grid-scale ultracapacitor has been built in mainland Great Britain to provide National Grid ESO with real-time on-demand inertia measurement. The GridMetric system went live as of July 2022 and measured inertia data is now available in the operator's control room.