COUNTRY : Ireland
REGISTRATION NUMBER : DLG5247

GROUP REF. : C4
PREF. SUBJECT : PS3
QUESTION N° : 20

What are the key design and control parameters of the battery and associated inverter to optimise the collective provision of system services such as frequency control, inertia, and system strength in a power system planning horizon?

For grid following controlled batteries EirGrid considers response time, droop gain and the frequency dead band are some of the important design and control parameters when it comes to frequency control. The effect of some of those control parameters is illustrated next.

In a loss of a generation event which happened on May 2021, we noticed that the system frequency remained below 49.8 Hz for almost 13 minutes (orange area in Figure 1 below) and below 50 Hz for almost 17 minutes (orange area + pink area in Figure 1 below).

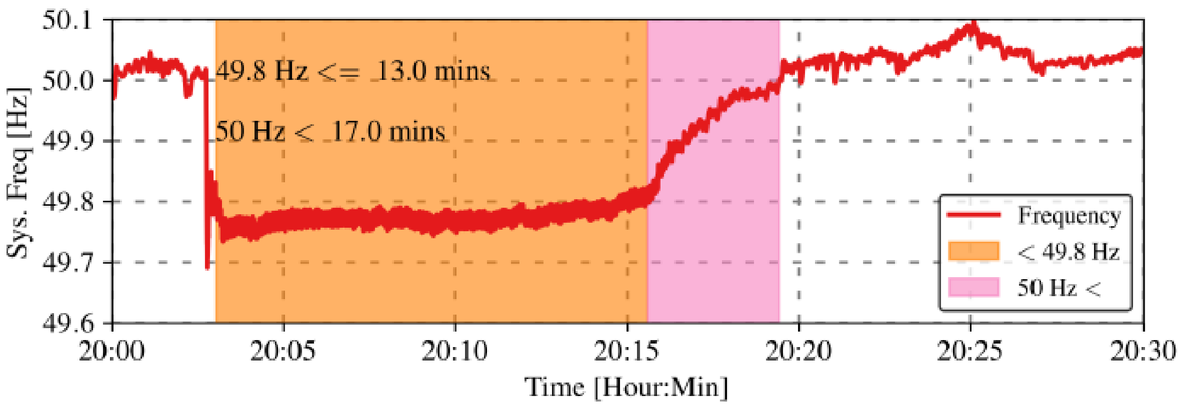

Figure 1 All island system frequency trace for 4th May 2021 incident.

Figure 2 shows the actual active power response of one battery (in red), expected battery active power response (in purple) and system frequency trace (in blue). The battery provided almost 9 MW of support (at peak) and it was set to a discharging mode three times within 20 seconds.

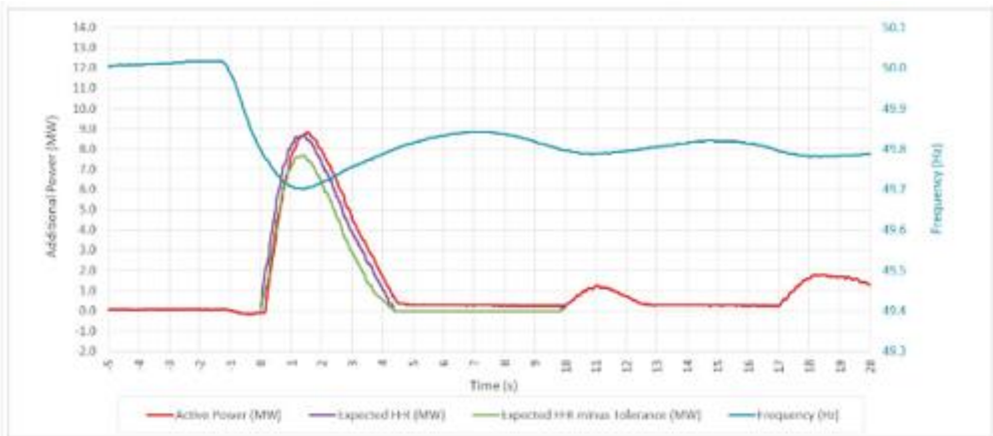

Figure 2 Battery response for 4th May 2021 incident.

We performed studies on battery control parameter settings vs frequency quality mainly focusing on frequency trigger and droop settings. We found that the trigger frequency of 49.8 Hz and low droop gain did not recover the system frequency above 49.8 for this event shown in Figure 3 (green trace with 49.8 Hz and red trace with 49.9 Hz interconnectors frequency threshold). Vice versa, with a trigger frequency of 49.9 Hz and high droop gain, system frequency recovered above 49.8 Hz quickly, resulting in higher frequency nadir shown in Figure 4 (green trace with 49.8 Hz and red trace with 49.9 Hz interconnectors frequency threshold). However, the complete discharging of batteries and an increase in the number of charging/discharging cycles is of concern. After this study, some of batteries control setting were changed to trigger frequency of 49.9 Hz and higher droop gain.

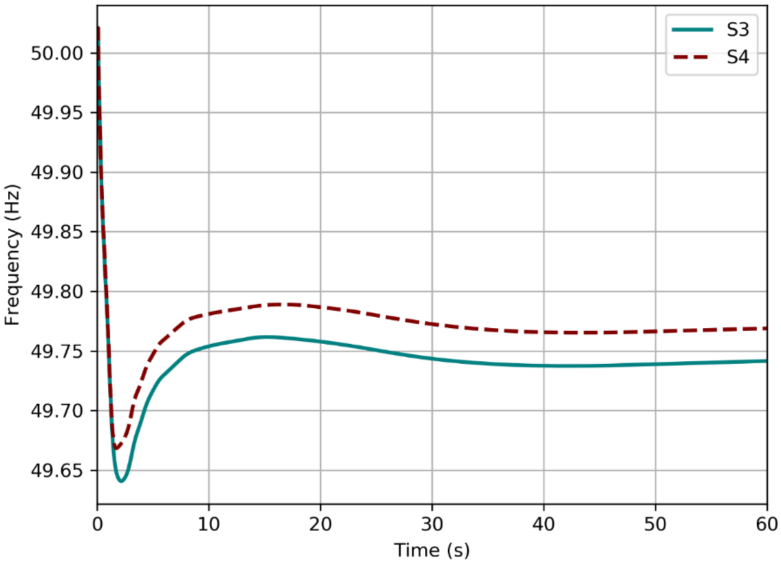

Figure 3 Battery response for 49.8Hz frequency trigger.

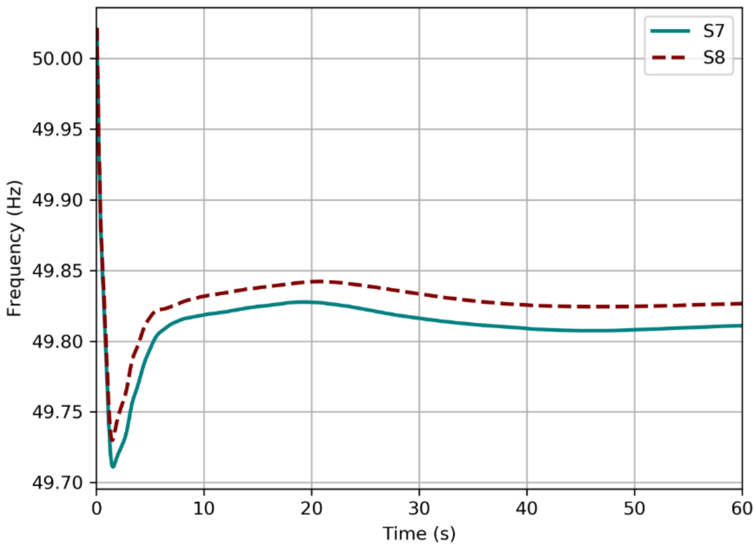

Figure 4 Battery response for 49.9Hz frequency trigger.

We are currently developing grid forming IBRs models. In this project we have carried out several survey and hardware in the loop simulations. We found that the grid forming IBRs can exhibit both inertia and frequency control. The inertia gain and droop gain are important parameters for optimising inertia and frequency response. The bandwidth of the outer voltage control loop should be designed a decade slower than the inner current loop to avoid converter instabilities. The grid forming IBRs are voltage source-controlled converters and that means they would contribute to system strength. The grid forming IBRs can behave like a Thevenin source and impedance with a converter over-current capacity limit. The short-term overcurrent capability is important design parameter for the grid forming IBRs. During faults, the grid forming IBRs provide a large fast current and may reach their converter over-current capacity limit.