User Spotlight Series 2.0: Q&A Document

Episode 2 – January 26, 2022

“Grid-Supporting Battery Energy Storage System - Modelling and Simulation in RTDS: An Australian Case Study” by University of New South Wales

Answers provided by presenters from University of New South Wales

Q1: Have you included indicative protection within your generic models? In respect of the VSM, have you adopted a particular approach to overcurrent management (e.g. virtual resistance modulation / clipping)?

For Stage 1, generic modeling, we have considered indicative over- and under-frequency and over-voltage protection schemes in both solar and wind farm. However, for Stages 2 and 3– after adjusting the rating of SVCs, solar farms, and wind farm to match the plants in the real system–we needed to deactivate the protection schemes as they tripped for the obtained voltage oscillations. By further adjusting the generic models to detailed ones, we expect to see a reduction in the amplitude of the voltage oscillations, and thus, be able to activate the protection schemes again.

Regarding the battery with virtual synchronous machine (VSM) emulation. During Stages 1 and 2, we have not adopted any indicative approach to overcurrent management. We expect to consider overcurrent management and complete protection schemes when performing HiL testing in Stage 3, once implementing the updated firmware of the original equipment manufacturer solution.

Q2: Did you test the response across repeated faults against a state of charge assumption? Was the state of charge fixed throughout testing of all the BESS grid supporting functionalities?

During Stages 1 and 2, we performed a variety of tests for different operations of the battery (standby, charging, and discharging) and state of charge. In particular, we have not found any appreciable issue when related to the state of charge of the battery.

The dynamic model acceptance testing (DMAT, see: https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/modelling-requirements) performed for commercial projects, in Australia,

RTDS Technologies Inc.
150 Innovation Drive
Winnipeg, MB R3T 2E1
CANADA
+1 204 989 9700

requires testing at charging and discharging at ±1pu, ±0.5pu, ±0.05pu active power levels, and similar conditions can be considered for the real-time and HiL testing. No requirements are set on the state of charge of the battery.

Q3: In large networks where it is not practical to do HIL testing, how would you proceed to identify possible interaction issues – possibly based on offline simulation tools? Have you observed similar issues in studies with standard offline tools like PSS/e or PowerFactory?

As the power system generation mix shifts from synchronous generators to inverter-based resources (IBRs), the dynamic of the system is becoming more dependent of the fast response of power electronics. Unfortunately, RMS offline simulation tools such as PSS/E and DIgSILENT PowerFactory (RMS module) fail to account for subcycle phenomena and/or control interactions, which makes it difficult to identify possible IBR interaction issues. For example, for the case we have presented, interactions have been replicated when using PSCAD (offline EMT) with detailed models of IBRs, and not when using PSS/E with detailed (although in RMS) models of IBRs.

RMS simulations and studies can still be of used when screening possible IBR interaction issues. In a first approach, RMS models can be utilized to calculate the fault level in a particular point of the grid, to later obtain the short-circuit ratio (SCR). In case the SCR is low (e.g., $SCR < 3$), the area of interest can be modeled in EMT platforms (offline or real-time), to later analyze if there is any interaction. Finally, HiL simulations can be performed at later stages to test and validate any proposed method/control to mitigate the detected issues, before implementing it in the system.

<u>“Development of a Microgrid Controller for a Remote Off-Grid Power System in Northern Canada and Its Evaluation Using Hardware-in-the-Loop Simulations” by University of Manitoba</u>

Answers provided by presenters from University of Manitoba

Q4: What kind of tests are conducted to validate the PMS in CHIL testing?

We designed the tests to validate main PMS functions that include both dispatch functions and transitions. The dispatch functions include transferring of EMS commands (unit commitments/reference values) to primary controls, after subjecting to a number of constrains that depend on the mode of operation. Therefore, the tests were designed to

RTDS Technologies Inc.
150 Innovation Drive
Winnipeg, MB R3T 2E1
CANADA
+1 204 989 9700

trigger certain functions such as those that are expected to activate under minimum and maximum loading for diesel generators, at minimum and maximum battery SOC levels, under excess PV generation, etc. Scenarios to test transition functions included planned and unplanned diesel generation disconnection events, diesel generation synchronization, etc. The tests included different BESS and diesel generator operating modes (diesel grid-forming, battery grid-forming, solar energy curtailment, etc.). More details can be found here: http://hdl.handle.net/1993/36092

Q5: You mentioned that 2 diesel units have grid-forming control implemented. How did you model this low-level control algorithm / what was it based on?

We modeled the diesel generator exciter and speed governor based on the models provided in one of the cases developed by RTDS Technologies in [1]. In isochronous mode, voltage and frequency references are set to the nominal values. In droop mode, the governor and exciter are driven by droop control loops [2]. In addition to this, secondary control loops to slowly restore the nominal voltage and frequency values which deviated due to the deployment of droop control loops were implemented [2]. More details can be found here:

[1] O. Nzimako and A. Rajapakse, "Real time simulation of a microgrid with multiple distributed energy resources," 2016 International Conference on Cogeneration, Small Power Plants and District Energy (ICUE), 2016, pp. 1-6, doi: 10.1109/COGEN.2016.7728945.
[2] http://hdl.handle.net/1993/36092

Q6: How do you manage the black-starting of the network - I presume it would be the diesel gen only?

We considered black starting with diesel generation. We did not test black starting with the BESS, but it should be possible.

Q7: What platform was used for the EMS?

In this research, the EMS was implemented using Matlab on a normal PC. This was acceptable, as EMS commands were updated hourly. Ideally, we would use a small real-time automation controller to run the EMS to drive the Power Management System (PMS) implemented in the RTAC.

Q8: How much time did the controller take to send the commands using the GOOSE Messaging communication?

RTDS Technologies Inc.
150 Innovation Drive
Winnipeg, MB R3T 2E1
CANADA
+1 204 989 9700

We didn't take accurate measurements, but the round trip GOOSE communication time was in the range of 8-10 milliseconds. In this case, the round trip delay includes the time from the occurrence of the event in RTDS till the RTDS subscribes GOOSE messages coming from SEL RTAC. This delay can be affected by the network traffic and devices processing time.

Q9: Have you implemented the control in p.u. system?

No, the controls presented during the webinar were implemented in the actual engineering units. However, we recognize the benefits of implementing controls using p.u. system.

Q10: Is it possible to carry to such kind of CHIL for grid-level BESS used for functions such as Power Shift or ancillary services?

Yes, it is certainly possible to carry out CHIL for grid-level battery systems providing ancillary services. We have a case study document which describes a utility user of the RTDS Simulator who performed such tests, available here. Functionalities and services that can be tested include real and reactive power support, power factor correction, and reactive power shift or smoothing, among others.

Q11: Is there a plan to deploy the microgrid system in Manitoba?

There is currently a PV-diesel system there, but we don't believe there is currently a plan in place to integrate a battery system. But several companies involved in solar projects in Manitoba were interested in studying details of PV-Diesel-Battery systems, and supported us providing data and practical information.

RTDS Technologies Inc.
150 Innovation Drive
Winnipeg, MB R3T 2E1
CANADA
+1 204 989 9700