NIA Project Annual Progress Report Document

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Date of Submission

Jul 2024

Project Reference Number

NIA2_NGESO045

Project Progress

Project Title

RealSim: Real-Time Phasor-EMT Simulations

Project Reference Number

NIA2_NGESO045

Project Start Date

June 2023

Project Duration

1 year and 6 months

Nominated Project Contact(s)

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Scope

The penetration of inverter-based resources and HVDC interconnections are rapidly growing into the GB power system in line with the integration of more renewable resources. Phasor-domain power system models excel at simulating large mixed networks with fast computations, however there are limitations to identifying electromagnetic transients and oscillatory interaction issues occurring in the GB power grid.

This project aims to develop a real-time simulation of a region of GB power system (e.g., South Coast) in both phasor and EMT modes for transient stability assessments. It investigates when and where to use the phasor mode and EMT mode simulations for a given system condition and provide real-time simulation of the grid in that region for system stability & security and identification of stability risks.

Full implementation of the project outcomes could reduce the costs associated with the early-stage identification of control interaction issues, and proper parameter tuning, which would result in more secure and reliable system operation. It would help identify the stability issues that may not have been identified using phasor mode-only models. The grid reinforcement required to solve the control interaction between inverter-based resources may cost hundreds of millions in the future if the correct technical measures are not introduced.

The outputs of the project could also benefit consumers by reducing the risk of major power disruptions. It would enable a smooth transition to a decarbonised electricity network with greater renewable integration, improved planning and reduced energy bills for consumers.

Objectives

The project will deliver the following objectives through the four linked work packages:

1. Conduct the phasor-domain and EMT models of a part of GB power system suitable for real-time simulation studies
2. Understanding the differences between phasor and EMT models for power system stability issues
3. Develop a standard to identify when and where each phasor and EMT model of a region should be used, given a system

condition
4. Stability analysis based on real-time simulations e.g., for understanding the impact of controllers and their interactions on transient stability of the power system, and contingencies

Success Criteria

The project will be considered a success if it meets the following success criteria:

- Establishing ePHASORSIM model of the South Coast power system
- Establishing HYPERSIM model of the South Coast power system
- Real-time transient stability assessment of ePHASORSIM and HYPERSIM models
- A framework to identify when and where each phasor and EMT simulation tools should be used

Performance Compared to the Original Project Aims, Objectives and Success Criteria

National Grid Electricity System Operator ("NGESO") has endeavoured to prepare the published report ("Report") in respect of RealSim: Real-Time Phasor-EMT Simulations, NIA2_NGESO045 ("Project") in a manner which is, as far as possible, objective, using information collected and compiled by NG and its Project partners ("Publishers"). Any intellectual property rights developed in the course of the Project and used in the Report shall be owned by the Publishers (as agreed between NG and the Project partners).

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Project Summary

The RealSim project aims to enhance the modeling and analysis capabilities of the Great Britain (GB) power grid using Electromagnetic Transients (EMT) analysis. The project, structured into four distinct work packages (WPs), aims to develop sophisticated real-time simulation models and tools that can provide critical stability assessments. As of now, we have completed WP1 and most of WP2, laying a solid foundation for the remaining phases.

Work Package 1: Integration of PSCAD Model into HYPERSIM

Objective: Adapt and integrate the PSCAD model of the South Coast power system into the HYPERSIM environment, ensuring the model's accuracy and feasibility for real-time applications.

Tasks and Outcomes:

Task 1.1: Successfully established the HYPERSIM model by importing the PSCAD model of the South Coast region into OPAL-RT Technologies' environment. This involved transferring the model to a unified database for seamless integration.

Task 1.2: Adjusted the HYPERSIM model to address incompatibilities with PSCAD components, replacing unavailable blocks with equivalent HYPERSIM blocks, thus ensuring functional parity.

Task 1.3: Conducted offline execution of the HYPERSIM model for transient stability assessment, comparing steady-state results with the PSCAD model. Necessary adjustments were made to align both models' outputs.

Task 1.4: Explored hardware-in-the-loop (HIL) execution to assess practical applications. A feasibility study using electronic load emulators validated the model's performance in HIL mode, demonstrating the model's applicability in real-time scenarios.

Deliverables:

A comprehensive HYPERSIM simulation model of the South Coast power system, including LCC and VSC-HVDC lines, suitable for offline, HIL, and real-time simulations.

Detailed reports on the offline simulations and feasibility studies of HIL-based experiments.

Work Package 2: Integration of PSCAD Model into ePHASORSIM

Objective: Adapt the PSCAD model of the South Coast power system for the ePHASORSIM environment, enabling real-time stability assessments.

Tasks and Outcomes:

Task 2.1: Adjusted the PSCAD model to suit the ePHASORSIM solver, replacing non-standard controllers with equivalent models supported by OPAL-RT.

Task 2.2: Developed a pin data file to manage input/output signals and monitoring components, crucial for transient stability assessments.

Task 2.3: Integrated the adapted PSCAD model into the OPAL-RT real-time simulator using RT-LAB software, ensuring

synchronization and readiness for phasor mode simulations.
Task 2.4: Conducted offline execution of the ePHASORSIM model for validation, comparing it with the original PSCAD model to ensure accuracy. Necessary adjustments were made to align both models.
Task 2.5: Initiated a feasibility study for HIL execution, involving the integration of electronic load emulators controlled via Modbus or analogue communication. This phase is ongoing, with preliminary results indicating positive performance of the ePHASORSIM model in HIL mode.
Deliverables:

- Adjusted PSCAD model for ePHASORSIM.
- Pin data file for simulation purposes.
- Initial ePHASORSIM simulation model.
- Pending reports on offline simulations and HIL-based feasibility studies.

Next Steps
The next phases of the project will delve into the remaining work packages, focusing on:
WP3: Utilizing the developed models to create a real-time stability analysis tool. This phase will explore computational requirements, effectiveness at the regional grid level, and the feasibility of delivering timely EMT information for critical network analysis.
WP4: Establishing a comprehensive framework and standards for EMT stability analysis, setting the stage for developing a robust tool for real-time EMT analysis and reporting.
Conclusion
The completion of WP1 and the substantial progress in WP2 mark significant milestones in the project. The successful adaptation and validation of the PSCAD models into HYPERSIM and ePHASORSIM environments have demonstrated the feasibility of detailed EMT analysis. As we move forward, the focus will shift towards developing real-time stability tools and establishing foundational standards for future advancements in EMT analysis.

Required Modifications to the Planned Approach During the Course of the Project

No modifications required to the planned approach.

Lessons Learnt for Future Projects

In completing WP1 and most of WP2, the University of Warwick explored how we could model the GB network in the level of detail needed for EMT analysis. We started with our existing analytical model for stability analysis and added layers of complexity to make it EMT compatible. Having found that it was possible to capture EMT data in this way without affecting the original south coast network data, we've entered phase two of the project to develop our model further and validate its findings.

Next, we will be exploring the challenges and opportunities of using our model to create a tool to measure stability in real time – to for example help us, understand what kind of computational power would be required, whether it could be used effectively for regional grid level stability analysis, and if we could calculate EMT information quickly enough for the Control Room to use it for critical network analysis.

The last part of the project will be to develop a framework and standards for EMT analysis of stability, which will set the groundwork for the future development of a tool to provide real time EMT analysis and reporting.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

The WP1 deliverables have been summarized below:

- HYPERSIM simulation model of South Coast power system with different technologies (LCC and VSC-HVDC lines) for offline, HIL, and real-time simulation purpose
- Report on offline simulation of HYPERRSIM model and PSCAD model of South Coast power system.
- Report on feasibility study of HIL-based experiments of HYPERSIM model of South Coast power system.
- A full report has been delivered on completion of WP1 tasks earlier described

WP2 deliverables have been summarized below:

- Adjusted PSCAD version of South Coast power system model for use in ePHASORSIM environment.
- South Coast power system input/output pin data file for offline, HIL, and real-time simulation purposes.
- ePHASORSIM simulation model of South Coast power system for offline, HIL, and real-time simulation purpose.
- Report to be delivered on offline simulation of ePHASORSIM model and PSCAD model of South Coast power system.
- Report to be delivered on feasibility study of HIL-based experiments of ePHASORSIM model of South Coast power system.
- A full report will be delivered on completion of WP2 tasks earlier described.

Data Access

Details on how network or consumption data arising in the course of NIA funded projects can be requested by interested parties, and the terms on which such data will be made available by National Grid can be found in our publicly available “Data sharing policy related to NIC/NIA projects” and www.nationalgrideso.com/innovation.

National Grid Electricity System Operator already publishes much of the data arising from our NIC/NIA projects at www.smarternetworks.org. You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.

Foreground IPR

The following Foreground IPR will be generated from the project:

- Extended literature review report including all documented SSO events worldwide which will be uploaded to the Smarter Networks Portal
- A python-based tool automating the PSCAD scenario creation and simulation. The current version of the tool includes: Frequency scan screening tool, grey box implementation, multi scenario runs results visualization