Newsletter

Issue 24: April 2021

The National HVDC Centre

Welcome to the Spring edition of our newsletter. As our building extension progresses and our lives start returning to normal, the Centre is celebrating its 4th anniversary. This newsletter shares our work on topics ranging from: integrated offshore connections, software in-the-loop innovation, and safety in simulation. As always, please contact us if you'd like to find out more.

Safety in Simulation

Often one thinks of safety only while performing a physical task that might pose some threat to his/her wellbeing. When it comes to simulation or studies safety is not the first thought on the engineer's mind.

However, even in simulation, safety should be given priority here the concept of safety by design should be applied, especially when it comes to performing critical studies that determines the performance and safety of highly critical infrastructure like HVDC links and transmission assets. In these simulations all the safety margins and limits should be considered so to ensure the performance of these critical assets are assessed with utmost safety in mind.

With the increased emphasize on EMT and Real-time simulation (with physical equipment like control panels, amplifiers etc.) to de-risk the integration of

renewables and interconnectors - the criticality of safety consideration on these simulations are ever more increasing.

Hence, safety should be one of the top things to be considered by all the power system engineers performing critical simulation and studies across GB and the world.

Bharath Ponnalagan

Protection testing of new convertor control

ScottishPower Renewables demonstrated that wind power can restore a 'blacked out' section of the transmission network from its Dersalloch windfarm in South Ayrshire. The black start trial was conducted with project partner Siemens Gamesa Renewables Energy and in close collaboration with ScottishPower Energy Networks when it came to interact with the grid. The National HVDC Centre supported this, ensuring critical protection and performance testing of the grid by injecting physical relays that protected the transmission circuits being energised during the trials.

Tests were performed using a combination of state of the art RTDS® simulator and power amplifiers. During

testing, the HVDC Centre ensured de-risking of the trials by verifying specific settings of the transmission system protections to enable the black start trials.

More information is available on ScottishPower Renewables website at:
www.scottishpowerrenewables.com/pages/innovation.aspx

Bharath Ponnalagan

The National HVDC Centre

EERA-JP Offshore Wind Conference, and the Future of Interoperability

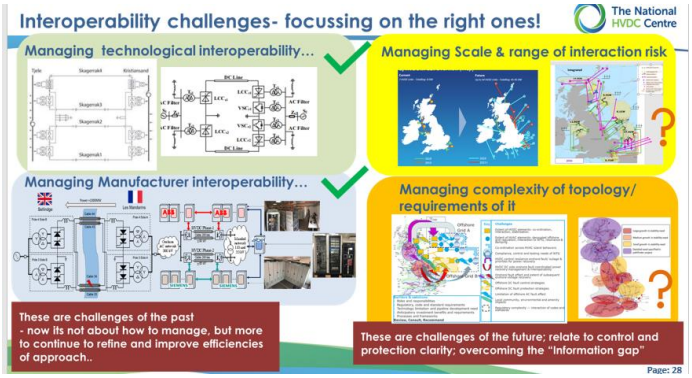
The National HVDC Centre presented at the EERA-JP Wind Conference on the opportunities that more complex, integrated HVDC solutions bring to operability challenges such as network stability, inertia and short circuit level support, but also how effective interoperability is achieved.

As we discussed, there are solutions for interoperability of technology and manufacturer that have been used to manage such risks (both within GB and elsewhere in the world).

The key future challenges come from the extent of functions new solutions need to be interoperable across and the scale at which solutions will need to evolve to support Net- Zero targets.

The solution to these challenges we advocate are:

1. Be clear, ahead of the detailed design stage, on what the functional requirements across the HVDC solution are, and equally clear how these need to be tested, monitored, and operated in practice;
2. Engage in an open interoperability dialogue between TSO and vendor where limitations and priorities in approach may be understood and discussed, such that the reasons for control solutions are understood and appreciated as they are developed;
3. Explore hosting of these solutions across design, test and implementation phase with sufficient completeness of model/hardware; and
4. Find new, innovative ways of doing this at scale- from mobile test approaches, to more open modelling in combination with reconfigurable hardware providing relevant insights on the key tests needed, and finding ways then to do them more efficiently.



The pace and scale of Offshore wind, onshore reinforcement and Interconnector growth in GB means that these are lessons we need to learn and deliver quickly; but which we have a strong experience and capability from which we can do so. The Conference discussed the many areas of learning necessary across this and other areas, such as floating turbine and wind grid forming capability and the role the recent Green Deal call may play in advancing these themes at a European level.

For further information, refer to: SP5 & SP6 WORKSHOP on System Integration – Expert Workshop: "Wind & Power-2-X" | EERA JP Wind

Ben Marshall

RTDS® "Software in the Loop"- A potential step-change in EMT simulation capability?

Over the past year, The National HVDC Centre has been discussing with RTDS Technologies Inc whether options enabling the integration of PSCAD® models inclusive of their code within a 'slower than real-time' timestep simulation could be engineered.

This approach, whilst unable to address fully the interoperability challenges we discuss earlier in the newsletter, has the potential to significantly speed up the simulation speed and computational flexibility involved in conducting large network analysis in PSCAD® involving multiple dynamic models.

The Centre will be working with RTDS Technologies in Beta tests of this "Software In the Loop" approach, using our state of the art NovaCor™ processors for which this new application has been developed. Beta tests will commence in Spring 2021, with us expecting to complete these towards the end of the Summer 2021.

Looking beyond the Beta test, should this approach prove successful, the Centre will look to feed back its findings to the joint TO and ESO delivered NIA project TOTEM, which Centre is also supporting. We will also be looking at ways in which this method may support developers confidentially integrating offline PSCAD® models into an environment similar in nature to our existing RTDS-HIL environment allowing IP and other modelling confidentialities to be robustly managed.

Finally we will be looking to explore further ways to augment this method RTDS Technology have developed into further limited areas of hardware interfacing- which would represent a "world first" for simulation platforms if the approach proves viable.

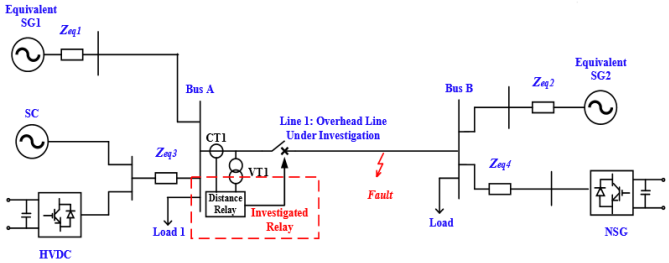
Ben Marshall and Habibur Rahman

AC Protection Interactions with Convertors

As shown in the National Trends and Insights (A System Operability Framework Document) from National Grid ESO (www.nationalgrideso.com/document/190151/download) the view to 2030 shows rapid increase in renewable generation and a sympathetic decrease in fault level; and this trend is likely to continue in the future decades.

The difference in fault characteristics of convertors (be it power electronic interfaced generation or indeed HVDC connected generation or interconnectors) compared to conventional plant is well documented, however, we are now approaching a point where the convertor infeed will dominate.

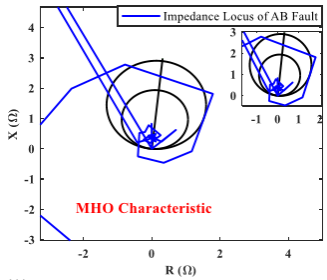
From the HVDC perspective we already know that this can cause control issues due to the poor performance of PLLs under fault conditions but coming to the system integration view the impact on the traditional AC protection relays is worthy of further consideration.



We recently hosted a joint webinar with Strathclyde where the reported on the project that we ran looking at evaluation of HVDC impact on AC network protection. This project provides a great RTDS HIL platform to test the operation of protection relays for a easily customisable mix of HVDC convertor, traditional fault levels and renewable energy sources.

A further aspect to this work was the sizing requirements for sync comps to improve fault characteristics. The studies done as part of the project identified that there are performance issues for distance protection relays where the fault currents are dominated by the convertor infeed.

Furthermore, the protection performance was affected by the control methodology adopted; multiple (grid code compliant) methodologies were assessed as part of the work. As the convertors can control the individual phase outputs it can confuse some of the internal relay algorithms developed with long standing traditional fault currents assumptions in mind. The erratic polar impedance plot as per the signals sent to a relay during a fault underline the difficult challenge that distance relays area faced with.



For all we now have tools to assess the problem in place and a good initial understanding of what the problem is that still leaves the solution to be found. To this end we are looking to launch a new NIA project looking deeper at this topic with a view to identifying the solutions.

Ian Cowan

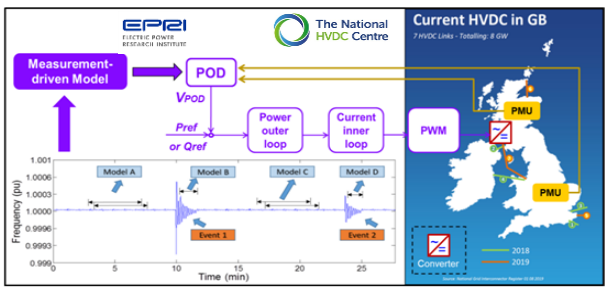
Project Update: Adaptive Power Oscillation Damping Control via HVDC/FACTS Devices

The increased integration of renewable sources and HVDC transmission links is significantly changing the characteristics of the Great Britain (GB) grid. These changes, resulting in reduced system inertia and frequent operating condition variations in the GB network, could potentially lead to oscillations across a wide frequency range. Therefore, these lead to system instability, system separation and widespread outage if the damping is inadequate. In 2020, The National HVDC Centre awarded Electric Power Research Institute (EPRI) to design adaptive power oscillation damping (POD) controllers via HVDC links and/or FACTS devices using a measurement-driven approach to support de-risking of HVDC projects in GB.

The key aim of the project is to implement the adaptive POD controller in a realistic reduced GB network model in a simulation platform. The performance of the POD controller will be investigated in different operating conditions of the network.

The National HVDC Centre is pleased to announce that earlier this month, EPRI delivered their first report on the validation of a reduced 36-bus GB network model in DIgSILENT PowerFactory environment where this model is used to conduct modal analysis, including oscillation frequency, damping ratio, mode shape, and their variations under different operating conditions. These analyses are the building blocks to identify the optimal location and design of the POD controller.

The full report is available at:
https://www.hvdccentre.com/pod_project/



The next stage of the work is to implement the hardware-in-the-loop test setup to demonstrate the POD controller performance in the real-time digital simulator (RTDS) platform.

Md Habibur Rahman

COMPOSITE Project Delivers Key Recommendations to the Industry

The COMPOSITE project on compliance testing of HVDC-connected offshore windfarms (OWF), which was commissioned by the HVDC Centre and delivered by RTE International (RTEi), has reported technical insights and recommendations to the ESO connections team.

The project investigated approaches for testing complex electricity connections comprising equipment/devices supplied by different manufacturers, in order to reduce grid integration and interoperability risks.

On 11 March, key learnings from the project were shared to over 240 stakeholders at a webcast, featuring technical presentations and panel discussions comprising representatives of an OWF developer, GB TOs and RTEi. The webcast video recordings, slides and technical insights are available here [1].

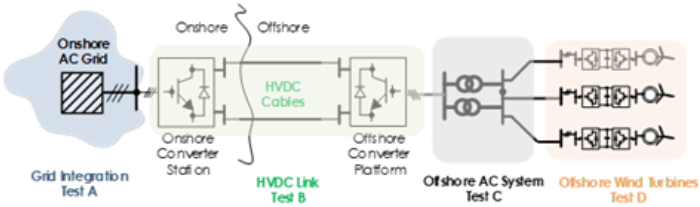
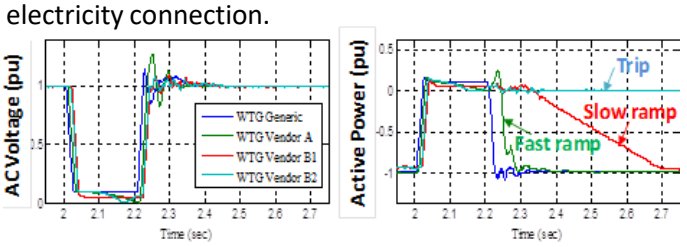


Fig: HVDC-connected offshore wind farm

Analysis of the offline EMT simulation results identifies that perfectly compliant wind farm models can respond differently when connected using offshore HVDC links. Coordinated design of control, protection and composite testing arrangements is required across OWF, HVDC link and onshore grid to de-risk complex electricity connection.



(a) (b)

Fig: Simulation results for a 3-phase to ground offshore AC fault F1 for 4 different wind farm models. (a) offshore AC voltage (pu); (b) active power (pu). Adapted from the full report [2].

As more projects share offshore transmission infrastructure, the COMPOSITE project findings will become more relevant, hence informing:

- Consistency of design across key stages of offshore connection project delivery;
- Compliance testing solutions for managing interoperability risks; and
- Clarity of offshore network technical and functional specifications.

References:

1. http://www.hvdccentre.com/composite/composite-webcast
2. https://www.hvdccentre.com/wp-content/uploads/2021/03/Composite-Testing-of-HVDC-connected-OWF_110321.pdf

Oluwole Daniel Adeuyi

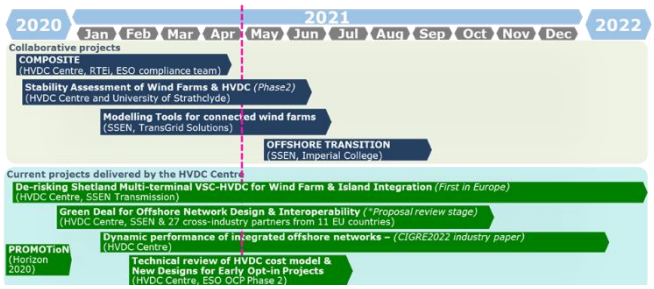
Progressing Integrated Offshore Network Solutions

The National HVDC Centre aims to support the technical design, analysis and de-risking of integrated offshore and onshore electricity connections in GB for all stakeholders (TOs, ESO, Project Developers and Equipment Manufacturers).

The Centre has actively led collaborative projects, supported delivery of integrated HVDC networks and contributed to technical consultations. Figure [right] is an illustration of ongoing technical activities at the HVDC Centre related to coordinated offshore networks.

As a result of trilateral discussions between The National HVDC Centre, BEIS and Ofgem on 9 March 2021, it was agreed that The National HVDC Centre would develop (with BEIS and Ofgem) the scope for an initial technical activity which would cover - functional design, analysis and demonstration of coordinated offshore network solutions and control schemes using generic reference models of the key components.

The HVDC Centre has also agreed to deliver a number of other reports to BEIS, including: a technical note on HVDC supply chain capability assessment, HVDC research and development strategy and strategic engagement at COP26.



The Centre delivered technical insights to the ESO on the development of a HVDC cost modelling tool for coordinated offshore networks. Also, the ESO commissioned the HVDC Centre to lead a technical activity on design-led early opportunities for offshore network coordination with final report due in May 2021, as part of the ongoing offshore transmission network review (OTNR).

Across the next 7 months, the HVDC Centre will deliver technical designs, insights and modelling tools to support all workstreams and stakeholders in the OTNR including early opportunities, pathway to 2030, enduring regime and multi-purpose interconnectors.

Oluwole Daniel Adeuyi

To find our more, please contact us to discuss or to arrange a visit:
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