Advanced Modelling and Simulation Tools at The National HVDC Centre

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The National HVDC Centre

Agenda

- **Who We Are and What We Do**
- **What We Have**
  - HVDC Replica, CMS Replica and Moyle Replica
  - GTSOC and Project Aquila
  - OPAL-RT and HVDC-WISE
  - PSCAD with High-Performance Computing and HVDC Centre inhouse Tool
- **Wrap-Up and Q&A**

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Who we are and What we do

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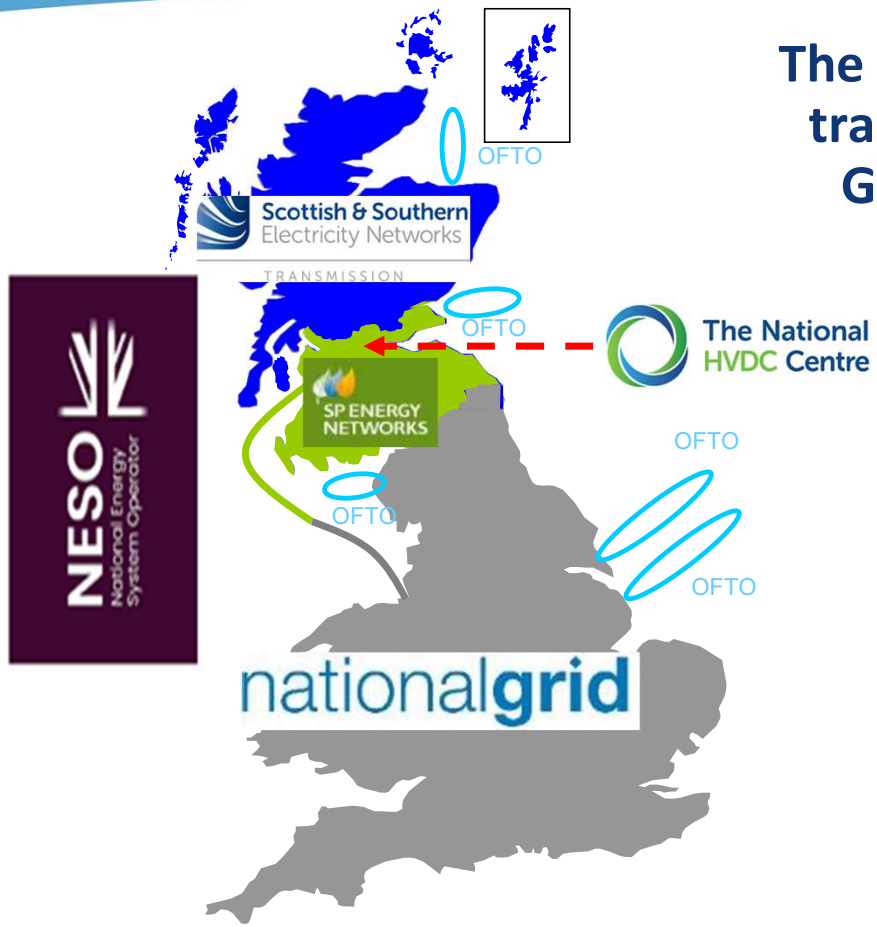

The National HVDC Centre delivers world-leading simulation, training and innovation to de-risk, accelerate and enhance GB's efficient transition to a resilient Net Zero network.

Bespoke Facility

Opened 2017
Extended 2022
Further extension planned

A Team of Industry Experts

World-Leading Simulation Infrastructure

- 11 x RTDS NovaCor Chassis & 3 PB5 Racks,
- 1 x OPAL-RT Rack
- 16 x GTSOCs, 3 x Power Amplifiers,
- 3 x High-Power Off-line Simulation PCs,
- Software: RSCAD, PSCAD, DIgSILENT, PSSE, MATLAB.

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Areas of Work

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Project Support

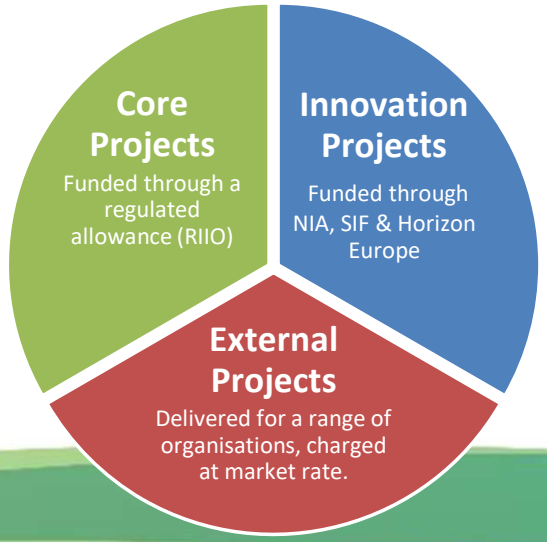
- Planning and design
- Commissioning
- Support ongoing changes
- Diagnose operational issues

Technology Leadership

- Multi-Terminal
- Multi-Vendor
- DC Circuit Breakers
- DC Grids
- Hybrid AC/DC network operation

Industry Leadership

- Training, Webinars, Publications
- Providing new tools for industry
- Supporting Grid Code development
- Academic Engagement
- Patenting to avoid supplier monopolies



Expanding to Meet GB's Need

- Support SSEN-T, SPT, NGET, interconnectors, offshore wind
- Requires increased simulation capability, replica hosting capacity, and resourcing

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What We Have:
HVDC Replica, CMS Replica and Moyle Replica

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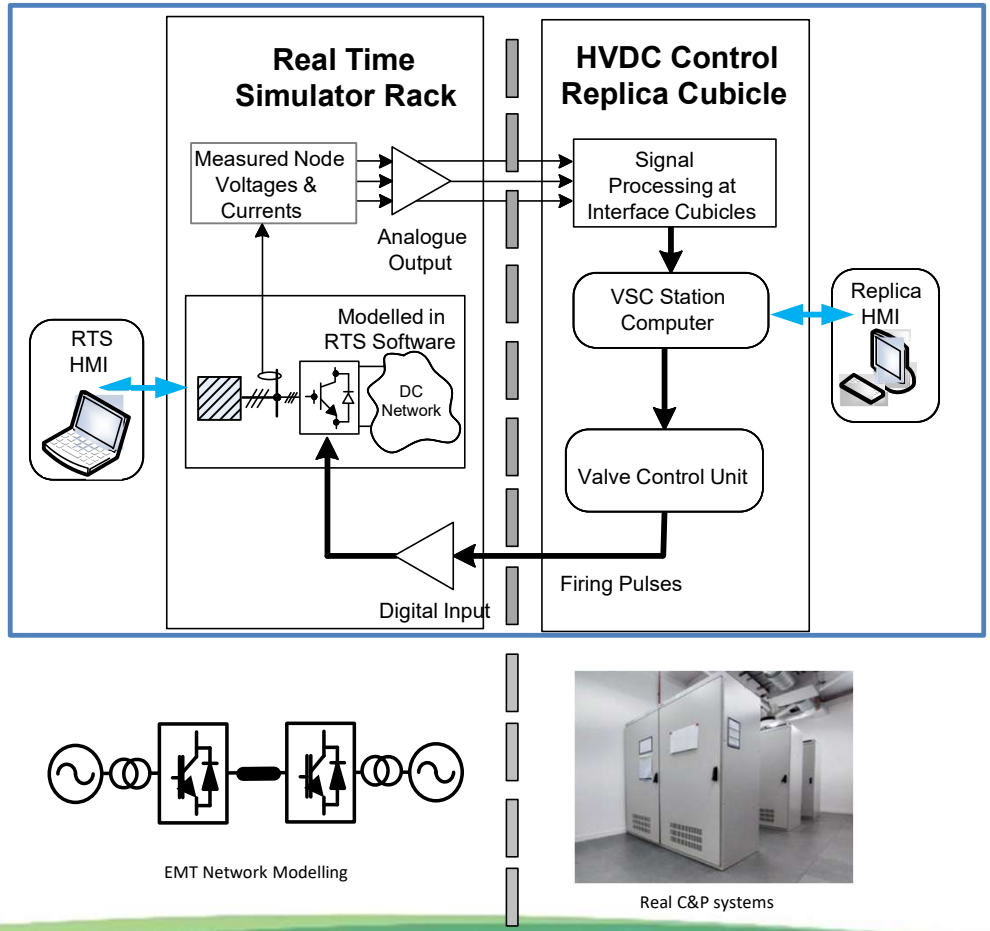
What is HVDC Replica



EMT Network Modelling

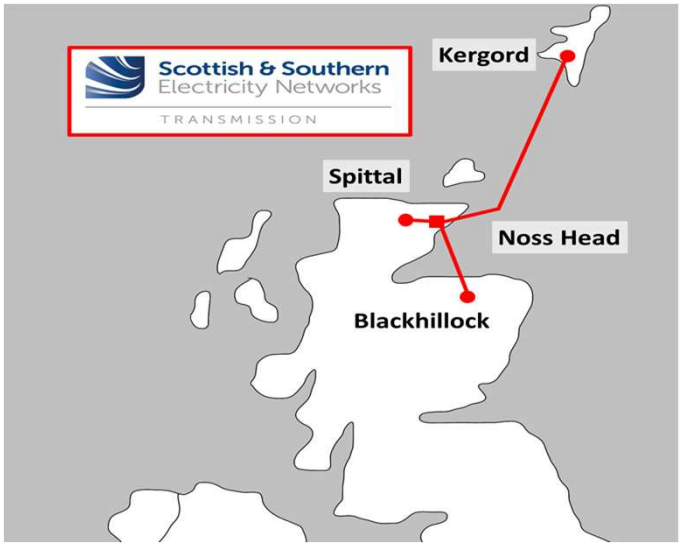
Real C&P systems

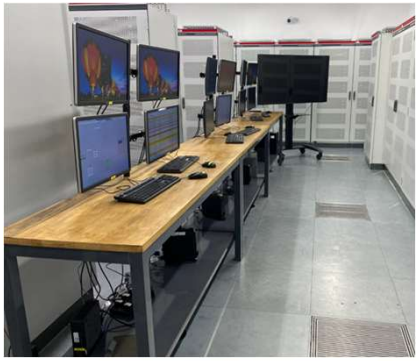
- Replica panels are physical duplicates of the Control & Protection (C&P) system — “hardware twins.”
- The HVDC main circuit is simulated using a real-time model (executing in microseconds) to replicate actual system behaviour.
- Signals are exchanged between the simulation model and vendor C&P systems via Hardware-in-the-Loop (HIL) integration.
- Multiple replica types exist:
  - Software-in-the-Loop (SIL) replicas, like GTSOC, IntervalZero

More details are available in the Centre’s webinar.

Webinar: HVDC Replicas Explained, Link: https://www.hvdccentre.com/films-list/webinar-hvdc-replicas-explained/

The CMS Link and the Its Replica





Caithness-Moray-Shetland HVDC Link

- Configuration: Symmetrical Monopole Multi-Terminal HVDC Link
- Vendor: Hitachi Energy
- DC Voltage Level: ±320 kV
- Stage 1: Caithness–Moray Link commissioned in 2018
- Stage 2A: Noss Head DC Switching Station commissioned in May 2023
- Stage 2B: Shetland (Kergord) Converter Station commissioned in August 2024
- First multi-terminal HVDC link outside of China

What can the CMS Replica do?

- Assist during commissioning
- Investigate proposed network changes
- Investigate proposed control and protection modifications
- Test scheme upgrades and refurbishment
- Train personnel on the scheme theory and operation

Caithness-Moray Project Support, Link: https://www.hvdccentre.com/hosting/caithness-moray-project-support/

Support for the Shetland Extension of the Caithness-Moray HVDC, Link: https://www.hvdccentre.com/our-projects/support-for-the-shetland-extension-of-the-caithness-moray-hvdc-link/

Moyle Link and Its Replica

Mutual Energy, Moyle Link and its Replica

- Mutual Energy is a mutual company which manages the Moyle Interconnector
- 500 MW Dual-Monopole LCC Link between:

  Ballycronan More (Northern Ireland)

  Auchencrosh (Scotland)
- Vendor: Siemens Energy
- DC Voltage: ±250 kV
- Length: 63.5 km (55 km Submarine cable)
- Commissioned in 2001, Replica installed at the HVDC Centre in December 2022 (Following Controller upgrade/Replacement on site)

Moyle Interconnector, Link: https://www.hvdccentre.com/hosting/moyle-interconnector/

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What We Have:
GTSOC and Project Aquila

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Project Aquila and GTSOC

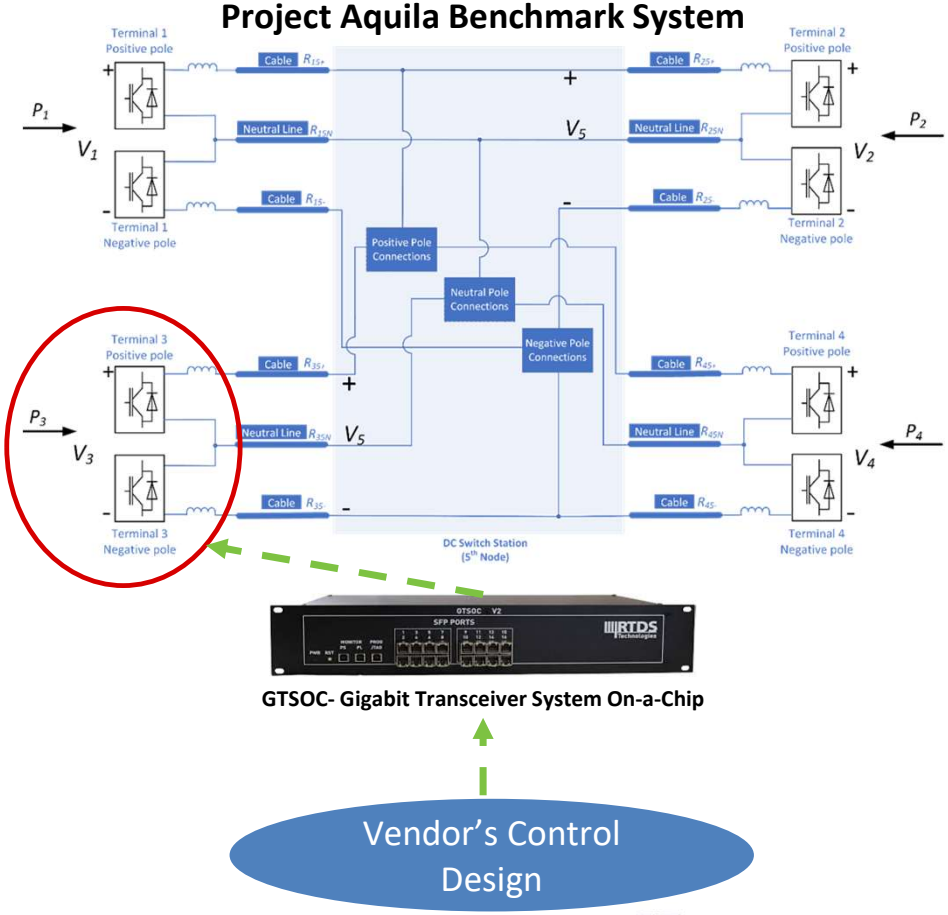
Project Aquila

- Demonstrates a multi-terminal, multi-vendor HVDC control solution for GB
- Specifies vendor-agnostic design to ensure interoperability with mathematically proven stability
- Lays the foundation for a scalable DC grid to grow in stages

Vendor Collaboration:

- Vendor supplied model to deliver specified interface performance
- Application of **GTSOC** (from RTDS Technologies, Software in the loop model) to allow encrypted vendor models
- HVDC Centre is an early adopter, hosting 16 GTSOCs to support current and future projects

Project Aquila Benchmark System



Aquila Interoperability Package, Link: https://www.hvdccentre.com/innovation-projects/aquila-interoperability-package/

Webinar: Introduction to Aquila Interoperability, Link: https://www.hvdccentre.com/films-list/introduction-to-aquila-interoperability/

What We Have:
OPAL-RT and HVDC-Wise

HVDC-WISE Project and OPAL-RT

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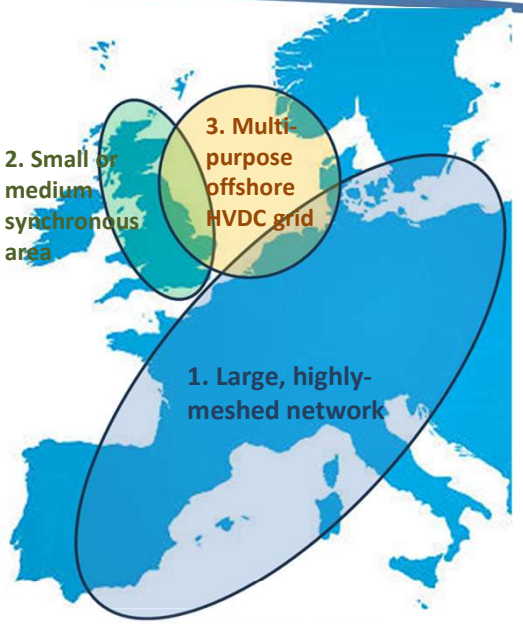
HVDC-WISE Project

- Enhance the Reliability and Resilience (R&R) of transmission systems by leverage the full potential of HVDC and reducing its inherent risks.
- Develop an R&R-oriented planning toolset to fulfil TSO needs for widespread AC/DC systems.
- Identify, assess and compare different HVDC-based grid architectures and emerging technologies.

Our Responsibilities:

- Investigate hybrid AC/DC grid configurations involving HVDC systems and power converters.
- Perform model reduction of the GB transmission network (Use Case 2) and develop a usable real-time EMT model.
- Simulate the large-area EMT network model in **OPAL-RT**, with potential for co-simulation with RTDS and Replicas.



Horizon Europe HVDC-WISE Project, Link: https://www.hvdccentre.com/innovation-projects/horizon-europe-hvdc-wise-project/

Resources from HVDC Wise, Link: https://hvdc-wise.eu/resources/

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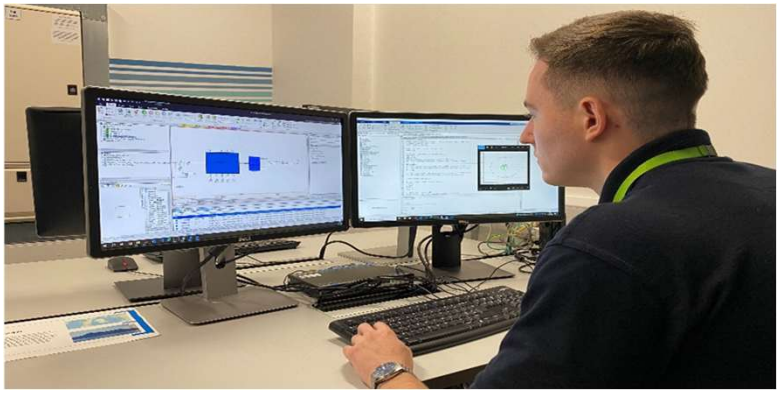
What We Have:
PSCAD with High-Performance Computing and HVDC Centre inhouse Tool

HPCs and What they can do

High Performance Computing (HPC) at the HVDC Centre

We have four HPCs be hosted at HVDC Centre, named after Scottish islands

- HPC Arran
- HPC Barra
- HPC Coll
- HPC Davaar



Why We Need HPCs for PSCAD Studies

PSCAD simulations for large-scale HVDC systems and detailed EMT models are highly computational and time-consuming.

This is due to the need for fine time-step resolution and solving complex differential equations to capture fast system dynamics.

High-Performance Computing (HPC) enables:

- Parallel processing of multiple scenarios
- Efficient handling of large and complex models

Without HPC, such studies may be impractical or too slow on standard machines.

HVDC Centre inhouse Tool

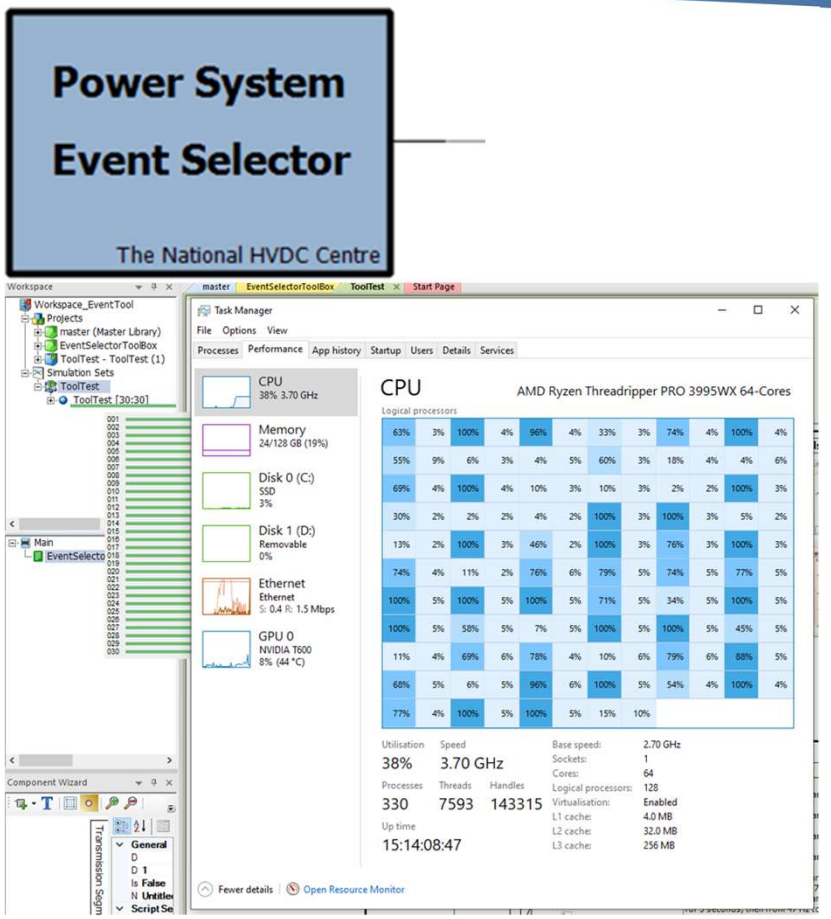
Power System Event Selector Toolbox

The Power System Event Selector Box is designed and supported for various grid-forming converter projects at the Centre, including:

- Project INCENTIVE – investigating GFM E-STATCOM and GFM BESS technologies.
- Project BLADE – exploring grid-forming technologies contributing to black start capability from offshore wind farms.

The tool supports simulation of various test scenarios recommended by the *Great Britain Grid Forming Best Practice Guide* published by NESO.

It can execute up to 64 tests simultaneously in a single run with our HPCs, significantly improving efficiency.



Project INCENTIVE, Link: https://www.hvdccentre.com/innovation-projects/incentive-innovative-control-and-energy-storage-for-ancillary-services-in-offshore-wind/

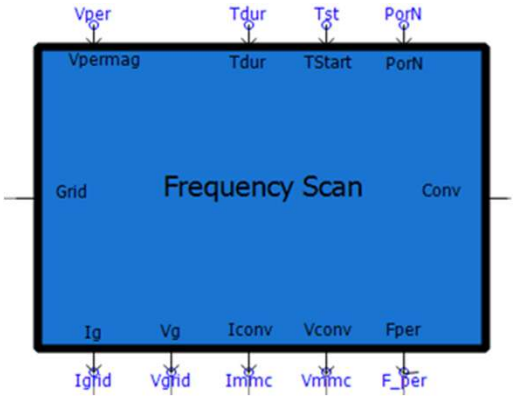
Project Blade, Link: https://www.hvdccentre.com/innovation-projects/blade/

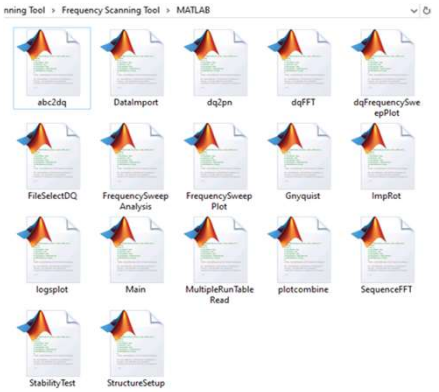
Weniars: https://www.hvdccentre.com/films-list/

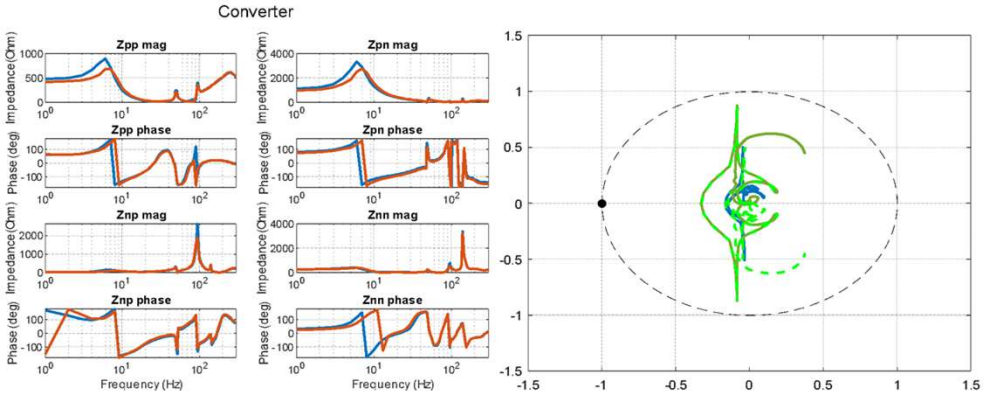
HVDC Centre inhouse Tool

Frequency Scanning Tool

- Small-signal analysis is a powerful technique used to assess the stability and dynamic behaviour of power converters, especially in HVDC and power-electronic-dominated systems.
- It helps with:
  - Understanding control interactions between converters and the grid
  - Identifying resonances and potential instabilities
  - Supporting engineers in designing future-proof systems
- The HVDC Centre has developed a small-signal analysis tool using the NESO-recommended MIMO approach.
- The tool performs frequency scanning in PSCAD, and analyses results in MATLAB, including support for Nyquist and Bode plots for stability assessment.







Webinar: Small Signal Analysis Studies (Jun 2024), Link: https://www.hvdccentre.com/films-list/small-signal-analysis-studies-webinar/

Wrap up and Conclusion

The National HVDC Centre is the UK's premier facility for testing, innovation, research, and training—driving Great Britain's transition to a resilient Net Zero energy system.

We host a wide range of world-leading simulation and modelling tools, enabling cutting-edge studies and solutions that accelerate progress toward this goal.

Ultimately, it's the people behind the technology who make Net Zero possible—driving innovation and delivering real-world solutions.

The National HVDC Centre Website, Link: https://www.hvdccentre.com/

HVDC Centre LinkedIn Page: https://www.linkedin.com/company/the-national-hvdc-centre/