PROMOTioN
PROGRESS ON MESHED HVDC OFFSHORE TRANSMISSION NETWORKS

WP 16 Demonstration – MMC CHiL testing

By Yongtao Yang

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 691714.

Agenda for the demo

11:30	Registration
12:00 – 13:00	Lunch & Opportunity to network
13:00 – 13:15	Welcome, *Theo Bosma, DNV GL*
13:15 – 13:30	Introduction to PROMOTioN, *Cornelis Plet, DNV GL*
13:30 – 13:50	Introduction to WP16 of PROMOTioN, *Philipp Ruffing, RWTH Aachen*
13:50 – 14:10	Test set-up, methodology & results of MMC HVDC Controller Hardware-in-the-Loop testing, *Yongtao Yang, DNV GL*
14:10 – 14:40	MMC HVDC Technology in China, *Eric Zhang, NR Electric*
14:40 – 15:00	Transport to Flex Power Grid Laboratory (incl. safety briefing)
15:00 – 16:30	Demonstration of MMC HVDC converter harmonic impedance measurement and dynamic performance, *FPGL Team, DNV GL*
16:30 – 17:00	Transport to building B50 and Arnhem Central station

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Content

- **Motivation for Control Hardware-in-the-loop testing**
- **Setup of CHIL Testbench for MMC-HVDC/MMC-STATCOM**
- **Update of CHIL Testbench of MMC-HVDC/MMC-STATCOM**

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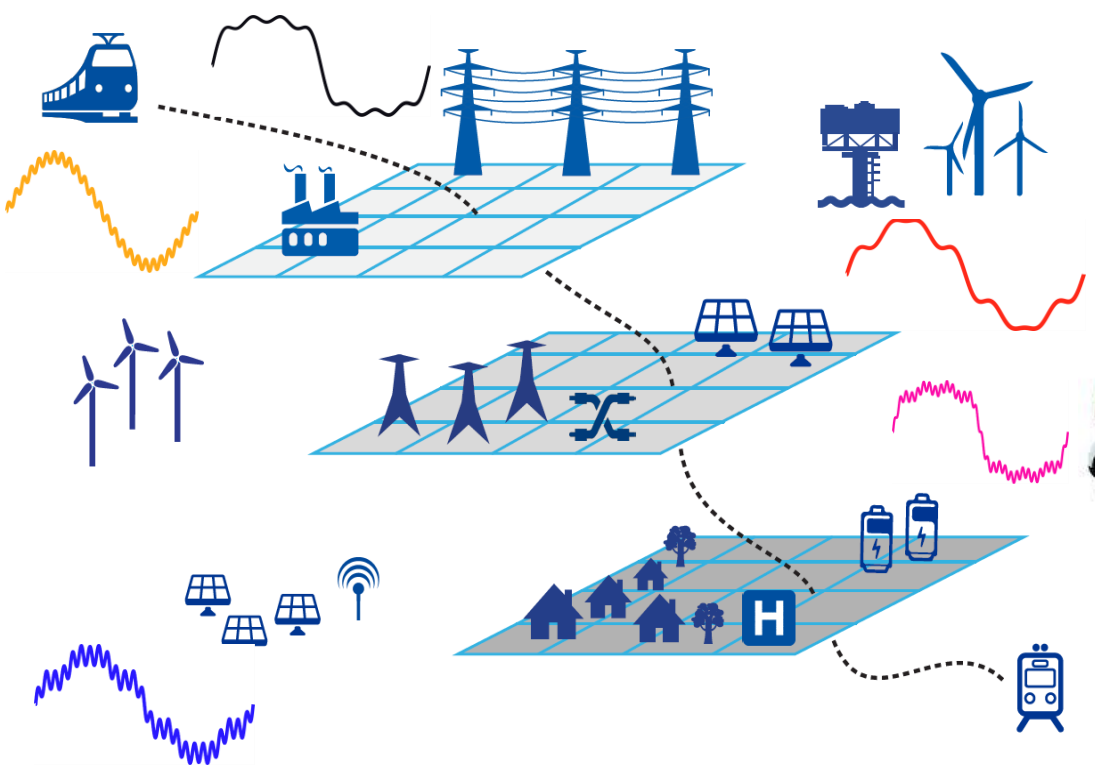
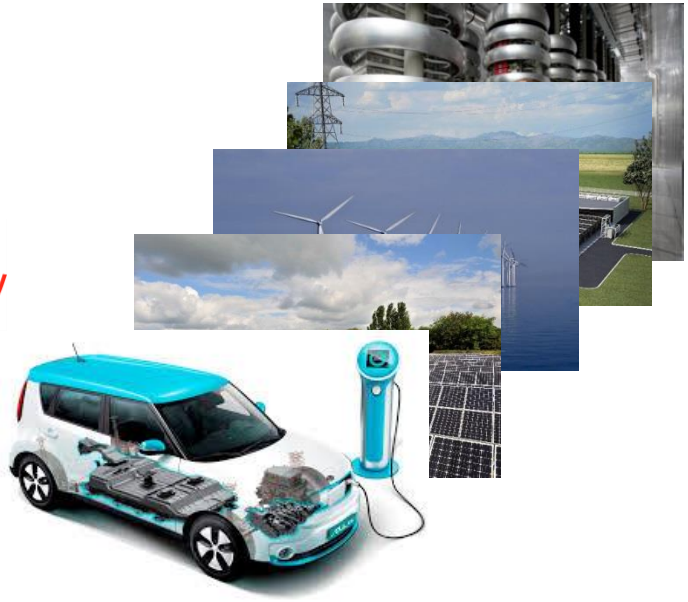
Motivation – Power Electronics Grid





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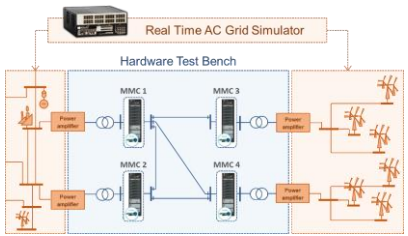
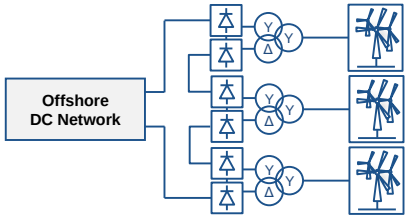
Deliverable D16.5

Implementation of an analytical method for analysis of harmonic resonance phenomena

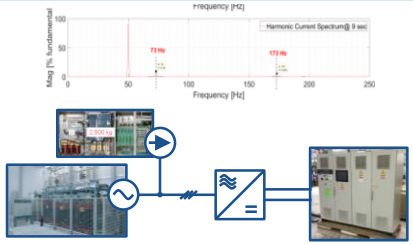
MMC-HVDC



Grid-forming WTG



Grid-following WTG



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MMC HVDC CHIL Testbench

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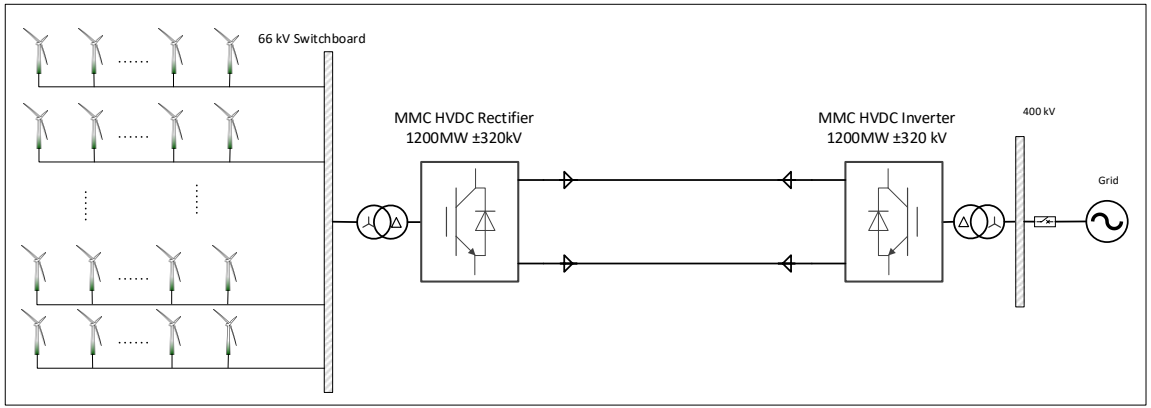
Objectives

Unit MMC resonance performance test

- Small signal perturbation test (injecting harmonic currents)
- Unit MMC converter operated as inverter/rectifier
- Validate the frequency domain performance measurement against theoretical models

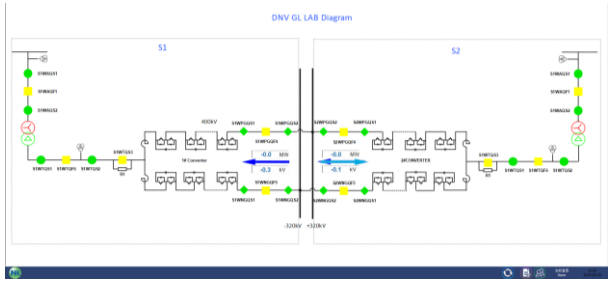


Offshore Wind Park (DC connection) Harmonic Resonance Analysis

- Using WTG controller scaled up to represent the whole park
- Investigate system level risk of harmonic resonance
- Covering different operation states, e.g. number of connected wind turbines/collector radials, different power levels etc.

AC Grid Support (Optional)

- Fault Ride Through (FRT) testing
- Frequency Support testing
- Power Oscillation Damping (POD) testing



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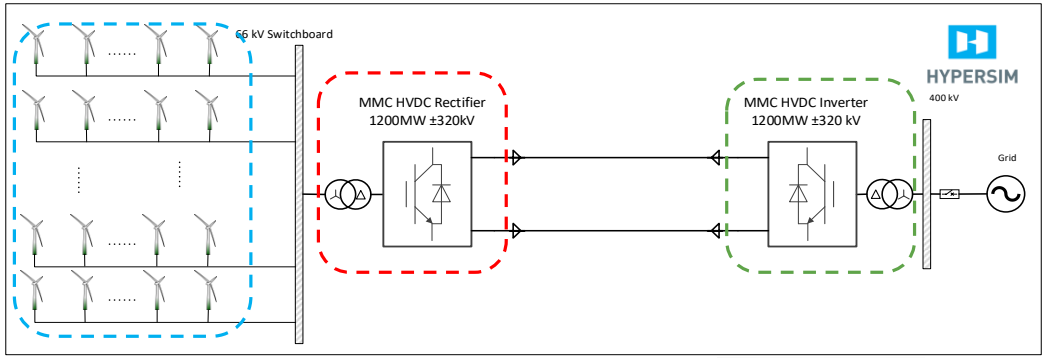
Demo 2.1 MMC HVDC CHiL Test bench

VBC – Valve Base Control
PCP – Pole Control & Protection



Digital signals
Analog signals
Fiber Optics

WT Converter Controller

OP 5700

PCIe

OP 7000

Station 1

VBC

PCP1

PCP2

Station 2

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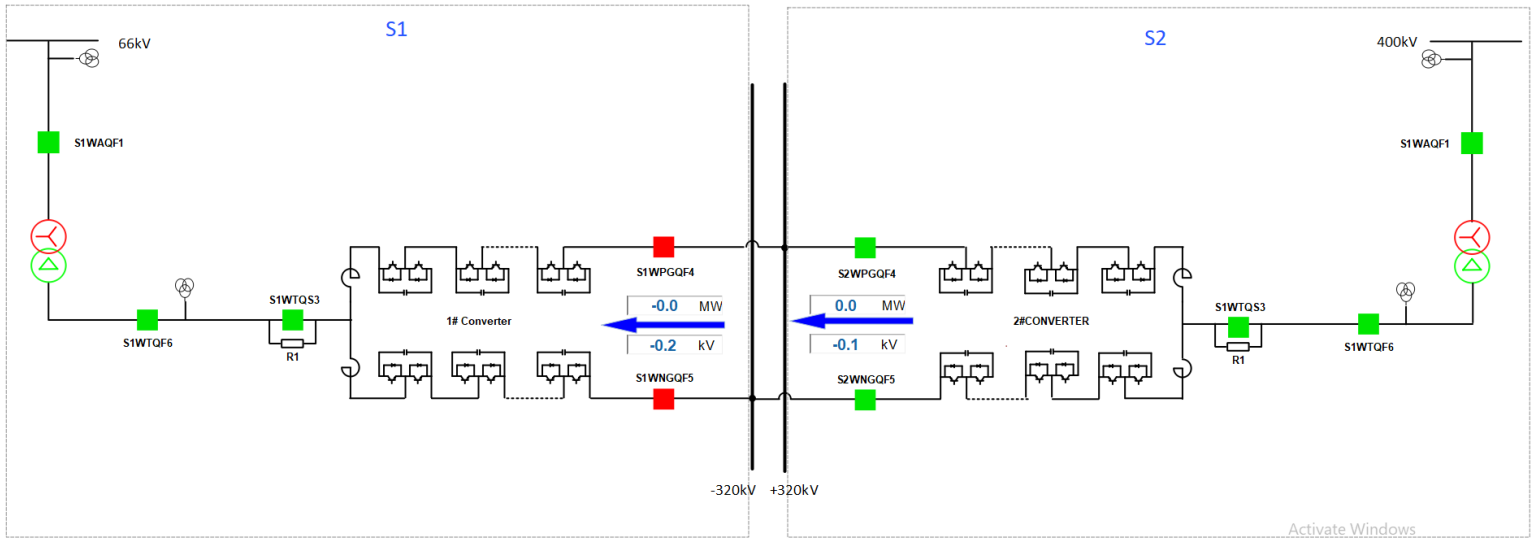
HMI from the NREC SCADA

DNV GL LAB	STATION 1						STATION 2						STATCOM						STATE	STATE	
	P_s	-0.000	MW	Q_s	-0.0	MVar	P_s	-0.000	MW	Q_s	-0.000	MVar	P_s	0.000	MW	Q_s	-0.000	MVar	S1PCP S2PCP	STATCOM	NR ELECTRIC
	I_v	8.174	A	U_v	0.235	kV	I_v	12.343	A	U_v	0.118	kV	I_{sa}	12.956	A	U_{sa}	1.472	kV			
	I_s	4.642	A	U_s	0.032	kV	I_s	0.570	A	U_s	0.136	kV	I_{sb}	7.292	A	U_{sb}	1.975	kV			
	I_d	1.505	A	U_{dc}	-0.223	kV	I_d	-2.085	A	U_{dc}	-0.101	kV	I_{sc}	9.320	A	U_{sc}	1.564	kV			

DNV GL LAB Diagram



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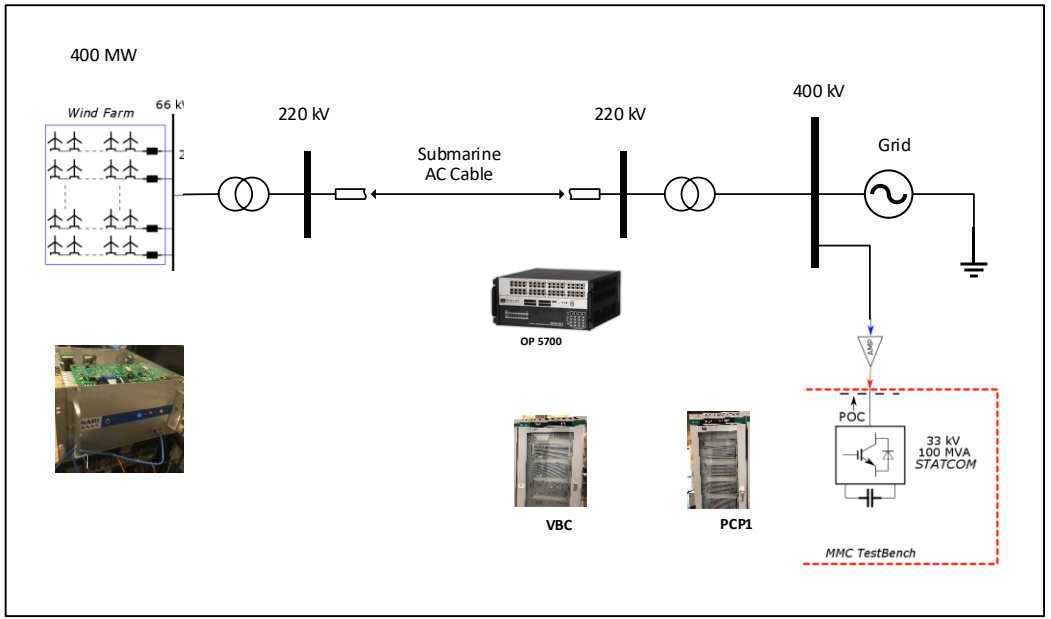
Objectives – AC Connected OWF with STATCOM

Unit MMC resonance performance test

- Small signal perturbation test (injecting harmonic currents)
- Unit MMC converter operated as inverter/rectifier
- Validate the frequency domain performance measurement against theoretical models

AC Grid Support

- Active Filtering
- Subsynchronous Oscillation Suppression
- Power Oscillation Damping



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Testcases and results of MMC CHiL

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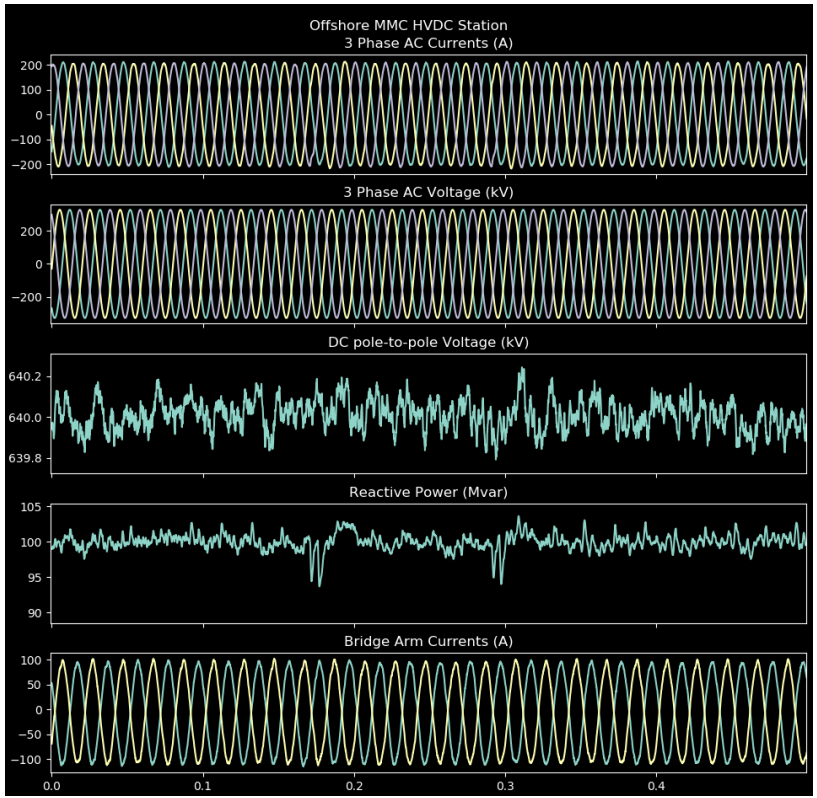
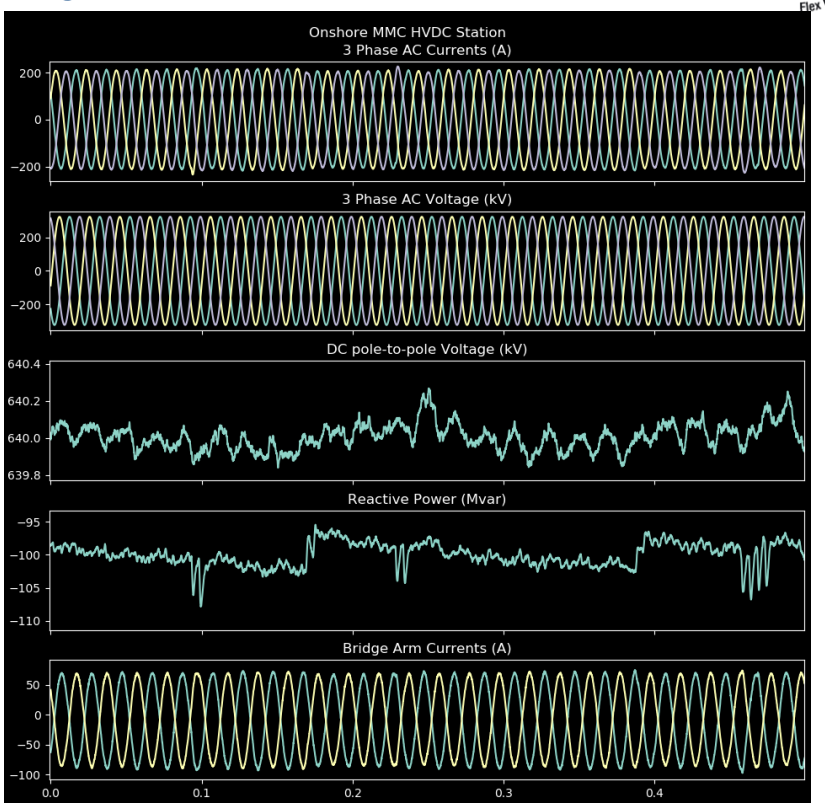
CHIL Measurement Results – Steady state 0MW





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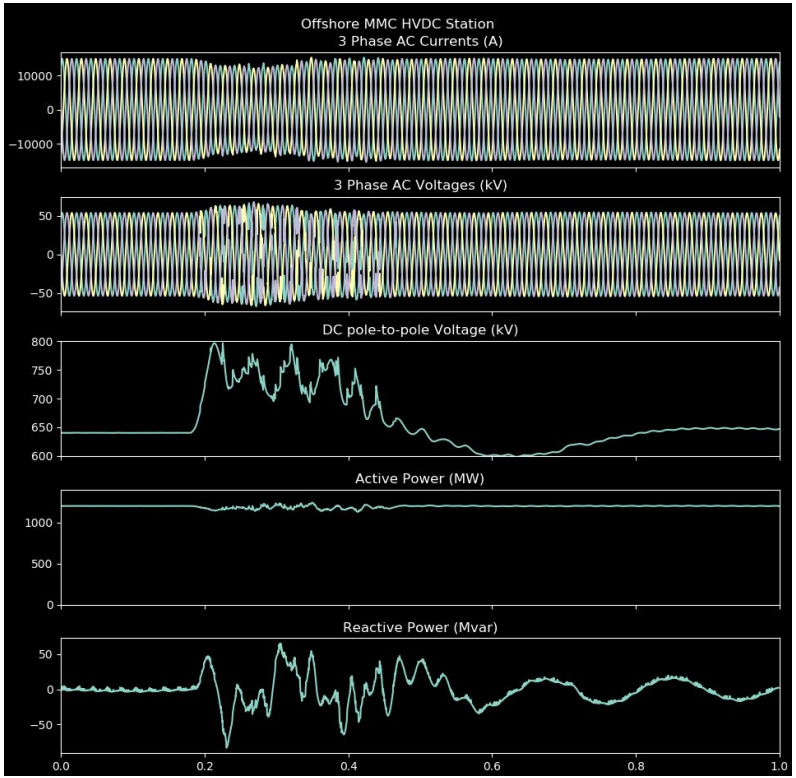
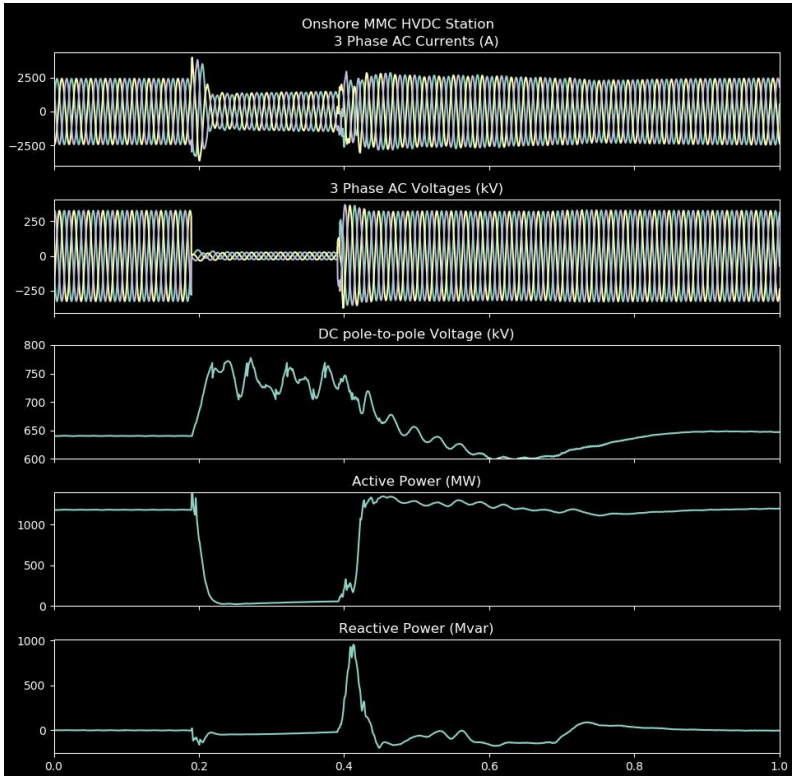
CHIL Measurement Results – Fault Ride Through





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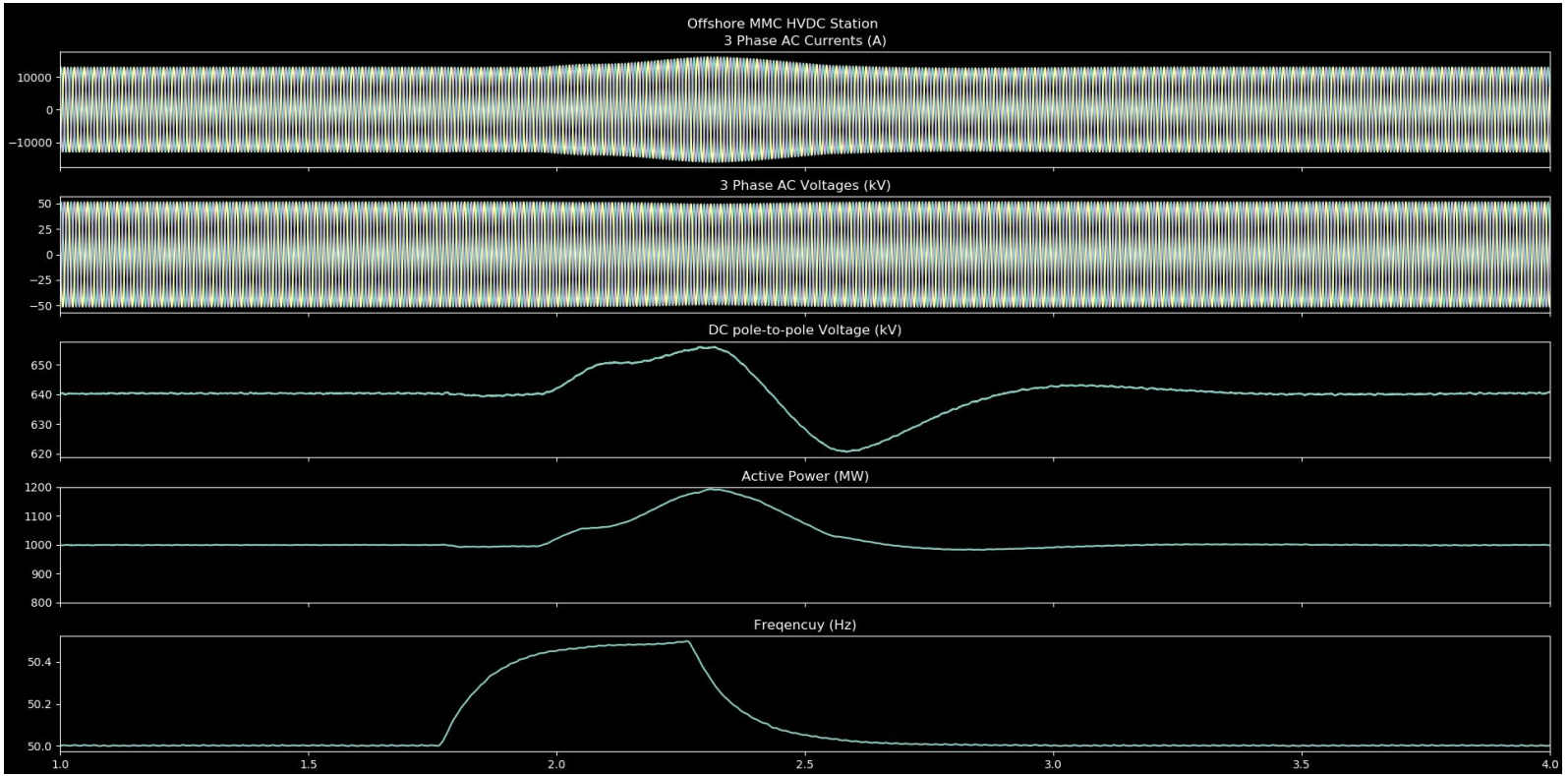
CHIL Measurement Results – Frequency Response



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APPENDIX

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PROJECT COORDINATOR

DNV GL Netherlands B.V.
Utrechtseweg 310, 6812 AR Arnhem, The Netherlands
Tel +31 26 3 56 9111
Web www.dnvgl.com/energy

CONTACT

DNV GL Team for WP16
Alejandra.Fabian@dnvgl.com
Andrew.Burstein@dnvgl.com
Andrew.Harson@dnvgl.com
Erik.deJong@dnvgl.com
Yin.Sun@dnvgl.com
Yongtao.Yang@dnvgl.com

PARTNERS

DNV GL Netherlands B.V., ABB AB, KU Leuven, KTH Royal Institute of Technology, EirGrid plc, SuperGrid Institute, Deutsche WindGuard GmbH, Mitsubishi Electric Europe B.V., Affärsverket Svenska kraftnät, Alstom Grid UK Ltd (Trading as GE Grid Solutions), University of Aberdeen, Réseau de Transport d'Électricité, Technische Universiteit Delft, Statoil ASA, TenneT TSO B.V., Stiftung OFFSHORE-WINDENERGIE, Siemens AG, Danmarks Tekniske Universitet, Rheinisch-Westfälische Technische Hochschule Aachen, Universitat Politècnica de València, SCiBreak AB, Forschungsgemeinschaft für. Elektrische Anlagen und Stromwirtschaft e.V., Ørsted Wind Power A/S, The Carbon Trust, Tractebel Engineering S.A., European University Institute, Iberdrola Renovables Energía, S.A., European Association of the Electricity Transmission & Distribution Equipment and Services Industry, University of Strathclyde, ADWEN Offshore, S.L., Prysmian, Rijksuniversiteit Groningen, MHI Vestas Offshore Wind AS, Energinet.dk, Scottish Hydro Electric Transmission plc, SCiBreak AB

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