7th InnoDC Meeting

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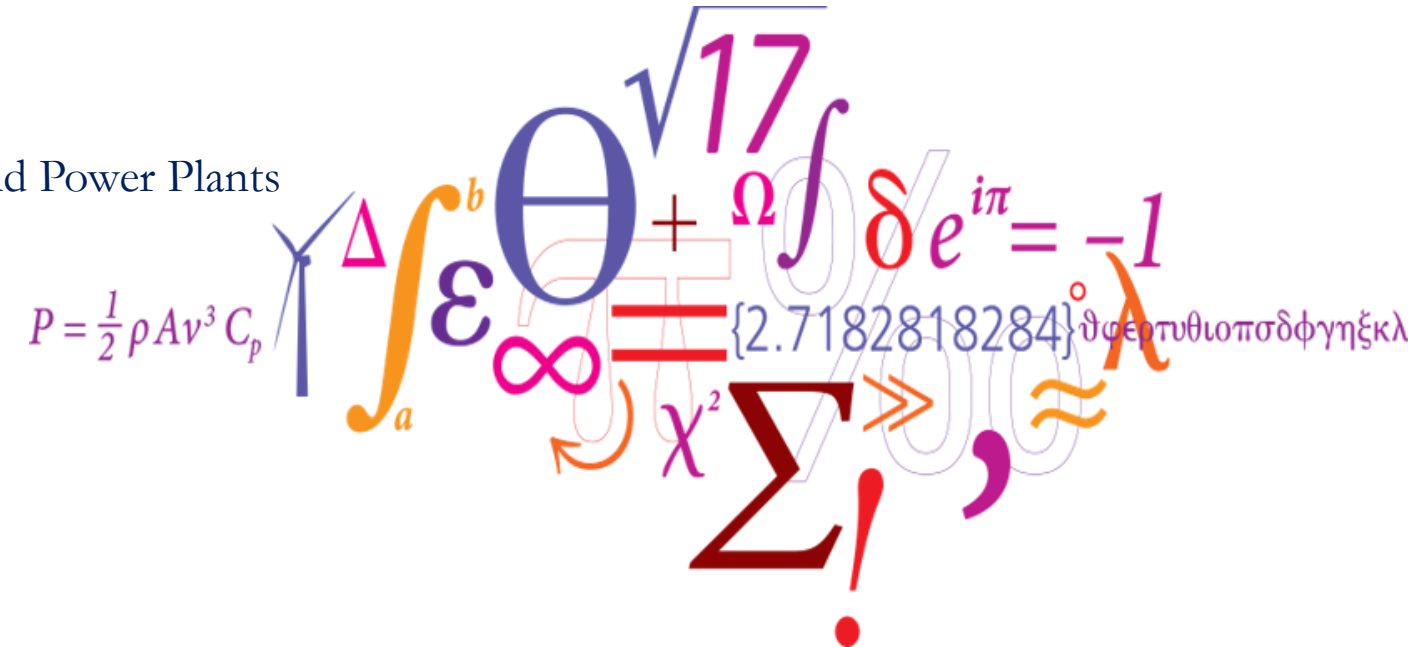
Anubhav Jain – ESR 15

Prof. Nicolaos A. Cutululis

Blackstart & Islanding capabilities of Offshore Wind Power Plants



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Publications

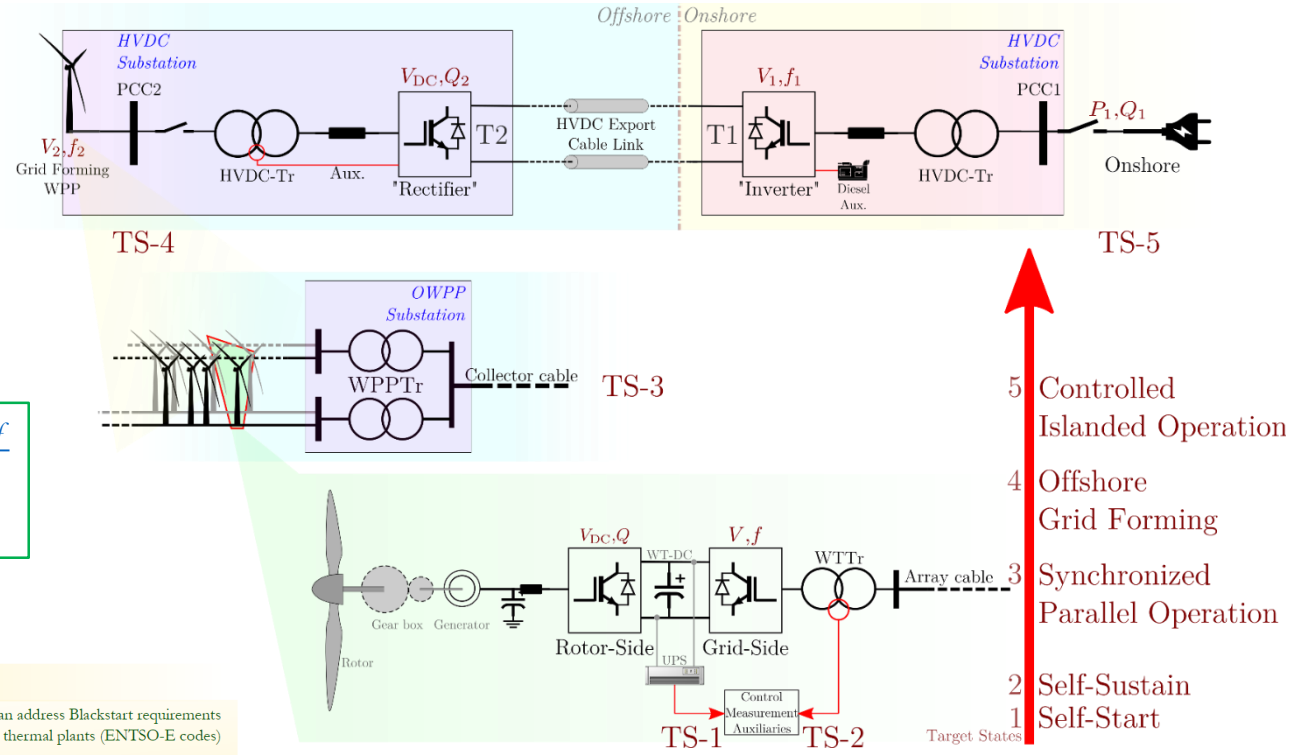
Problem Definition	• Motivation (TSO & WFO) • Define target states • Identify technical challenges & control solutions	*Control solutions for Blackstart capability and Islanding operation of Offshore wind power plants* *Proc. 17th Wind Integration Workshop 2018* DOI: 10.5281/zenodo.3269542
Functional Requirements	• Find gap between BSU grid code requirements & state-of-art WT capabilities	*Functional Requirements for Blackstart and Power System Restoration from Wind Power Plants* *Proc. 2nd Intl. Conf. of Large-Scale Grid Integration of Renewable Energy in India 2019* DOI: 10.5281/zenodo.3460518
Preliminary Results	• System model & control • Energization sequence (Greenstart)	*Black Start by HVdc-connected Offshore Wind Power Plants* *Proc. IECON – 45th Annual Conf. of IEEE Industrial Electronics Society 2019* DOI: 10.1109/IECON.2019.8927615
Grid Forming OWPP	• Implement different control strategies • Compare transient behaviour during greenstart	*Grid-forming control strategies for black start by offshore wind power plants* *in Wind Energy Science 2020 (EAWE): Spcl. Iss. WESC 2019* DOI: 10.5194/wes-5-1297-2020
Hard v Soft Energization	• Offshore network: PIR/PIT (hard) | Ramp-rate (soft) • Onshore MMC: controlled pre-charging.	*Blackstart from HVDC-connected Offshore Wind: Hard vs Soft Energization* *in Renewable Power Generation 2020 (IET)* DOI: 10.1049/rpg2.12010
Virtual Resistance	• Trafo inrush & sympathetic interaction transients for 1 WT & string energization	*Virtual Resistance Control for Sequential Greenstart of Offshore Wind Power Plants* *Submitted to Trans. Power Delivery 2021 (IEEE)* DOI: NA

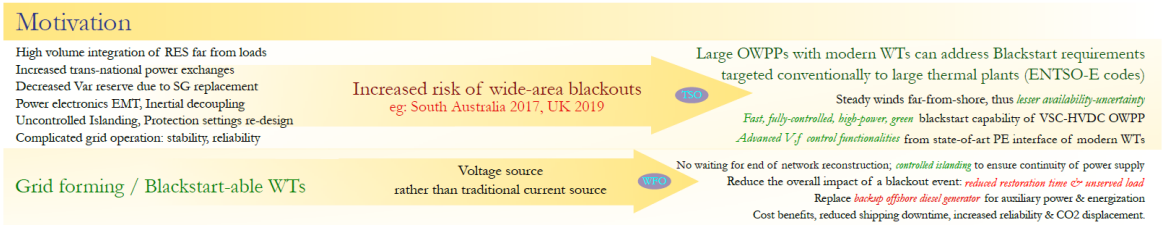
Problem Definition

Literature review:

- Motivation – TSO | WFO
- Greenstart Target States – challenges & solutions

[*Control solutions for Blackstart capability and Islanding operation of Offshore wind power plants*]
Proc. 17th Wind Integration Workshop (Stockholm) 2018





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Functional Requirements

Literature review:

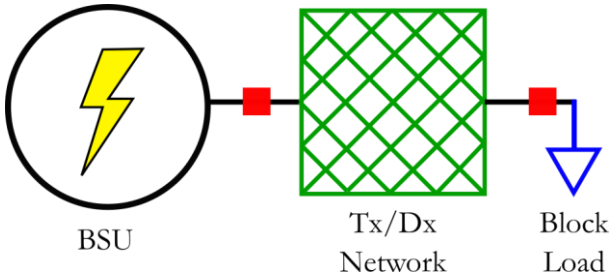
- Gap between BSU technical requirements & state-of-art WT capabilities.
- Future grid code recommendations.

System Energization

- Blackstart: Self-start, Fuel supply, Restoration time.
- V-propagation: Var-requirement, V-management.
- Load recovery: V, *f*-management

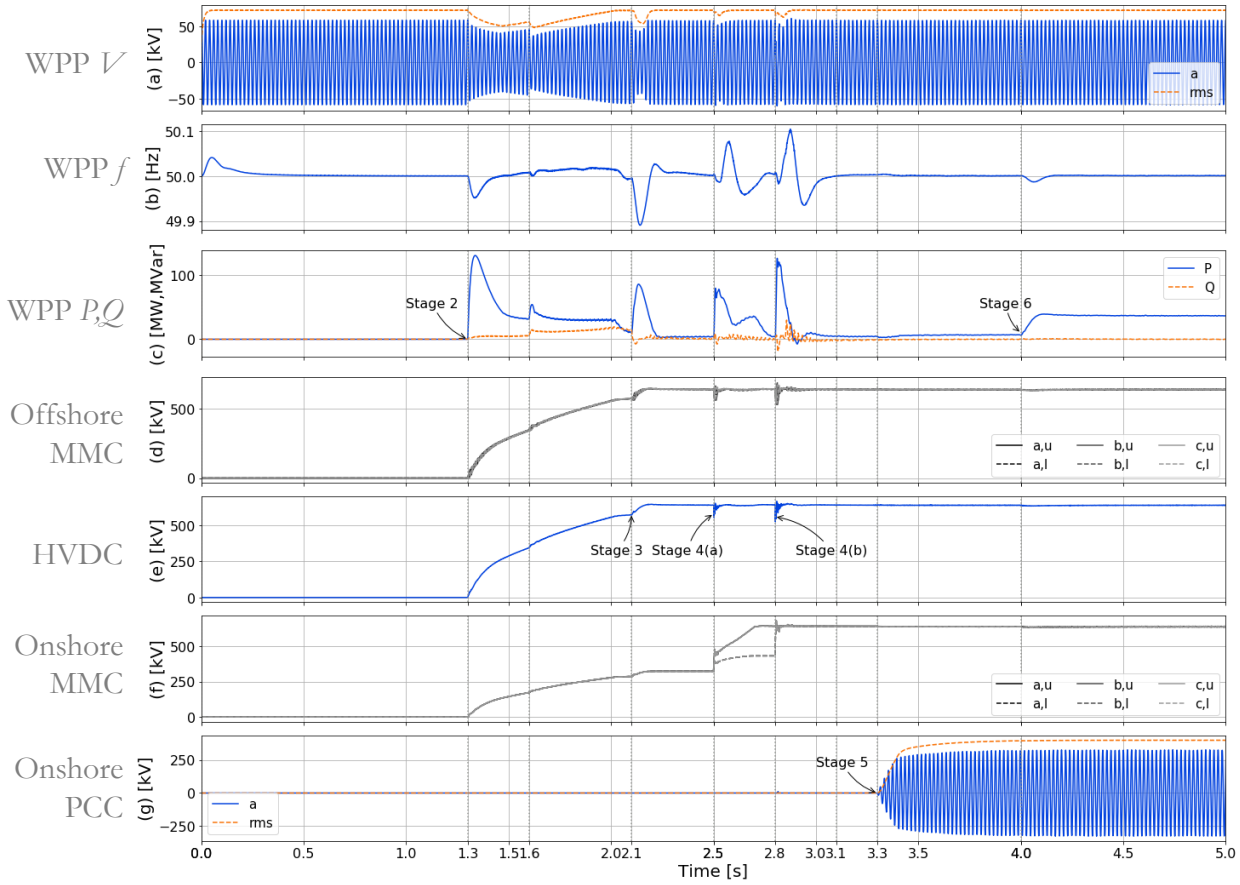
Load Restoration

- Block Loading: P-requirement.
- Islanding (CIO) & TTH
- Synchronization



Functional Requirements for Blackstart and Power System Restoration from Wind Power Plants
Proc. 2nd Intl. Conf. of Large-Scale Grid Integration of Renewable Energy in India (New Delhi) 2019

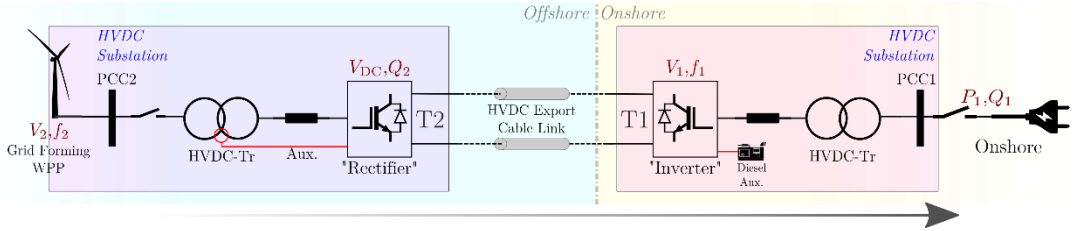
Greenstart Overview



Stages…

- WPP GFM
- Offshore Trafo & MMC
- HVDC link
- Onshore MMC
- Onshore PCC
- Block load

Black Start by HVdc-connected Offshore Wind Power Plants
Proc. IECON – 45th Annual Conf. of IEEE Industrial Electronics Society (Lisbon) 2019

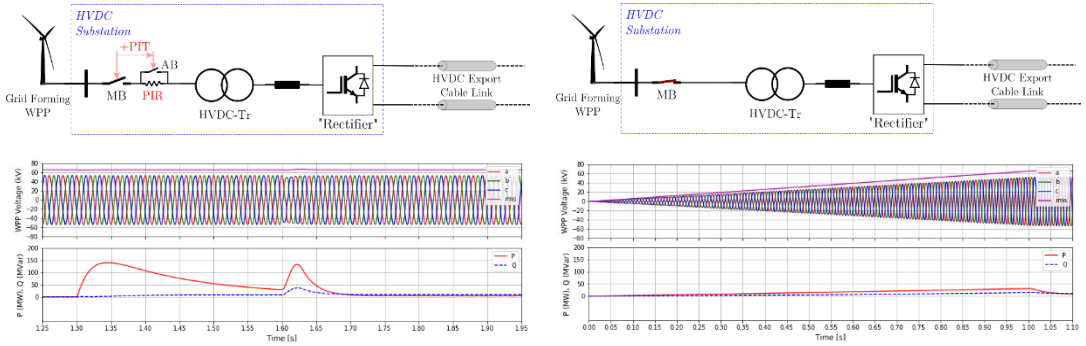


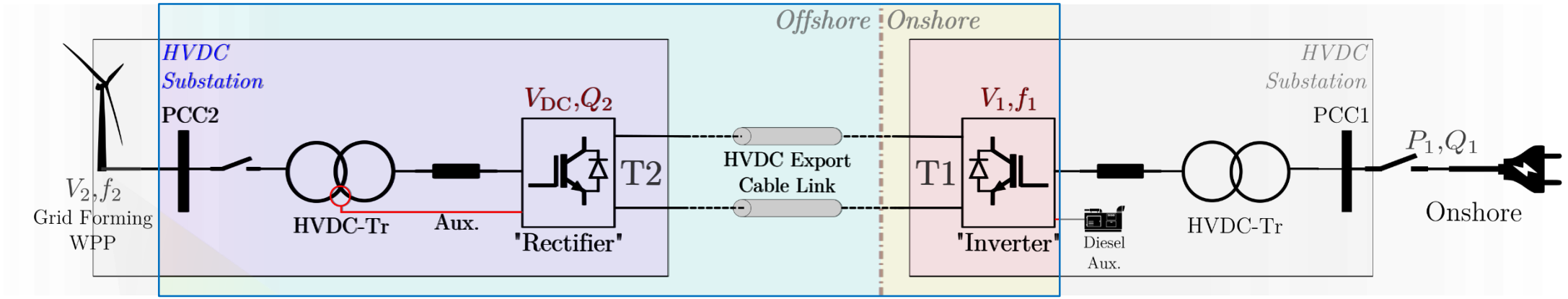
Hard v Soft Energization

Focus – offshore & HVDC transients:

- Offshore network: hard-switching vs soft-start.
- Onshore MMC: controlled pre-charging.
- Sensitivity analyses: PIR/PIT| Ramp-rate

Blackstart from HVDC-connected Offshore Wind: Hard vs Soft Energization
in Renewable Power Generation 2020 (IET/Wiley)



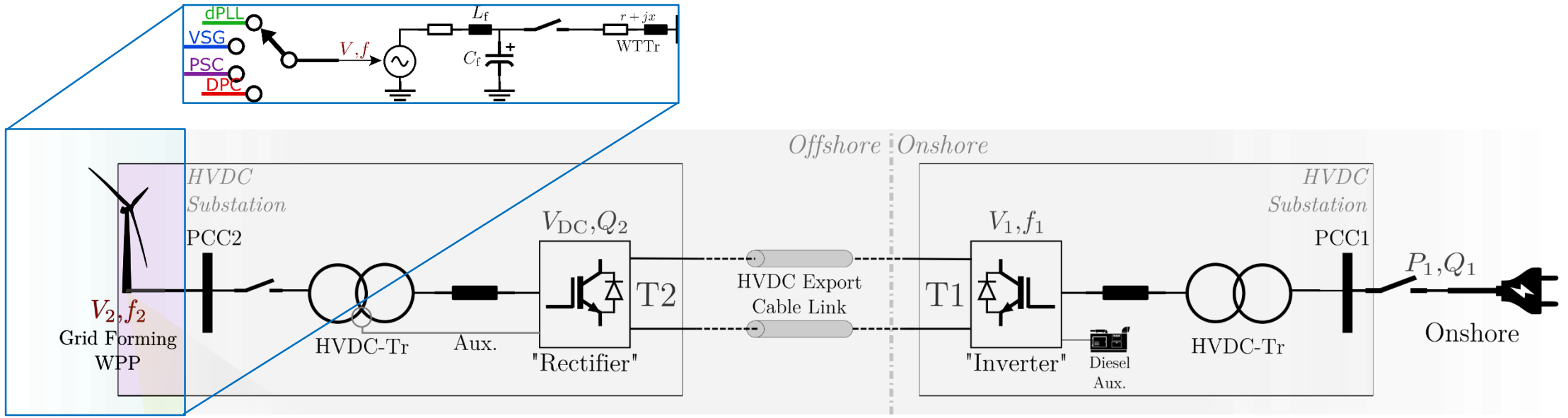


Grid Forming OWPP

Focus – WT GFM control:

- Implement different control strategies.
- Compare transient behaviour during energization.

Grid-forming control strategies for black start by offshore wind power plants
in Wind Energy Science 2020 (EAWE)
Spcl. Iss. WESC 2019

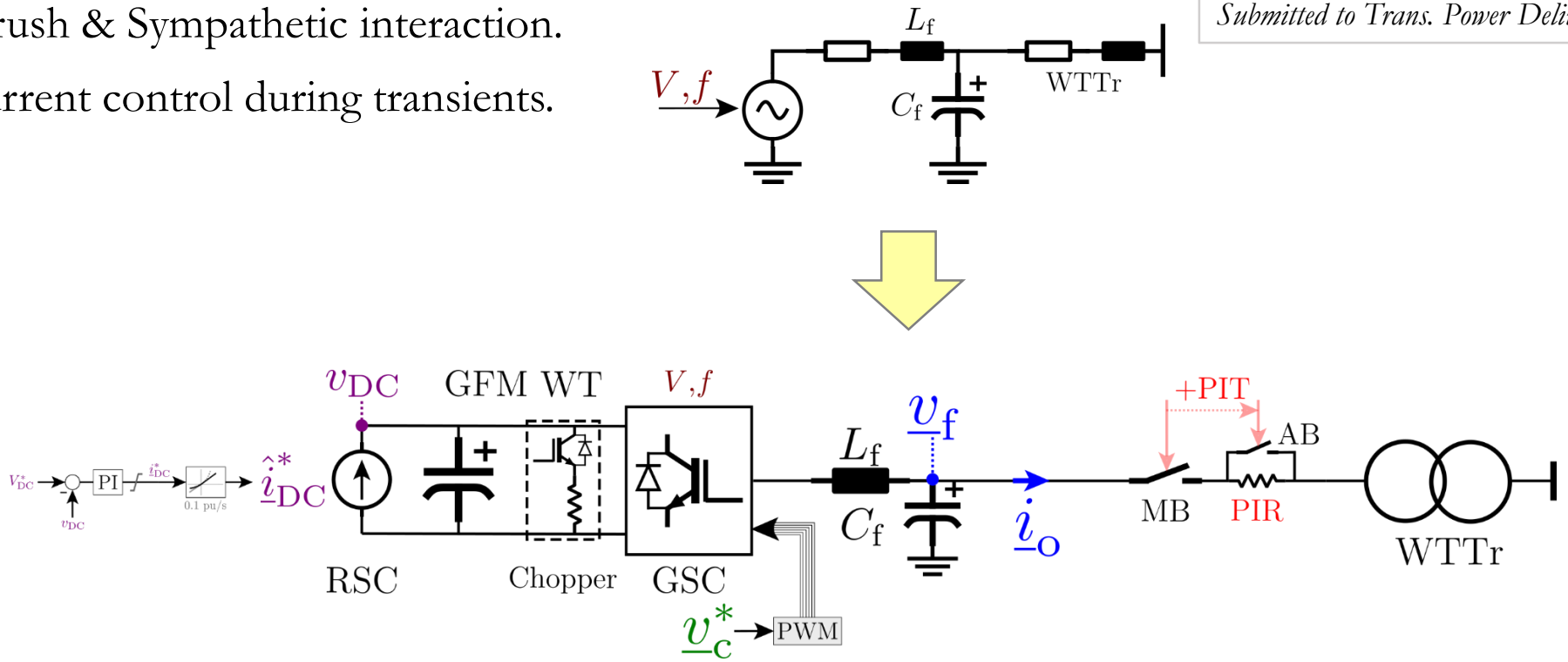


Virtual Resistance Control

Focus – WT Trafo connection:

- Inrush & Sympathetic interaction.
- Current control during transients.

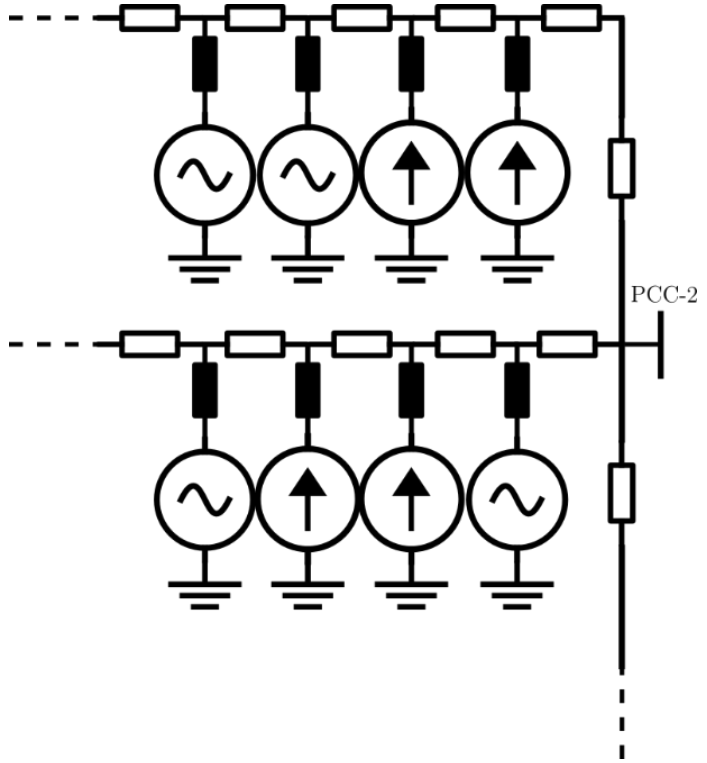
Virtual Resistance Control for Sequential Greenstart of Offshore Wind Power Plants Submitted to Trans. Power Delivery 2021 (IEEE)



Ongoing…

Inside the WPP…

- Sequential start-up of WTs → Synchronization transients
- Park level control for parallel operation (GFM + GFL)
- Islanding with OSS aux trafo & load



Thank You

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