Research, Demonstration and Commercialisation of DC Microgrid Technologies (RDC2MT)

Project Introduction

29th September 2018, Corfu

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 734796.

Context

- Introduction of Aston University
  - Aston University
  - Power Electronics, Machine and Power System (PEMPS) Group
- Introduction of Projects
  - RDC2MT
  - Other Relevant Projects
- Research
  - DC Microgrid Control and Stability

Introduction of Aston University

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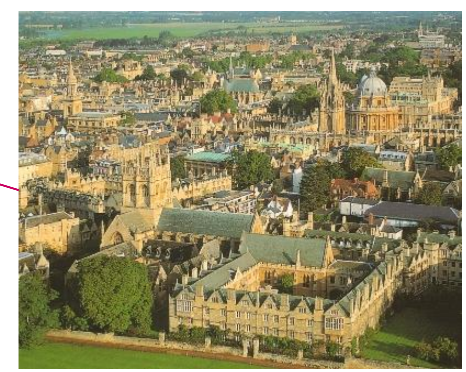
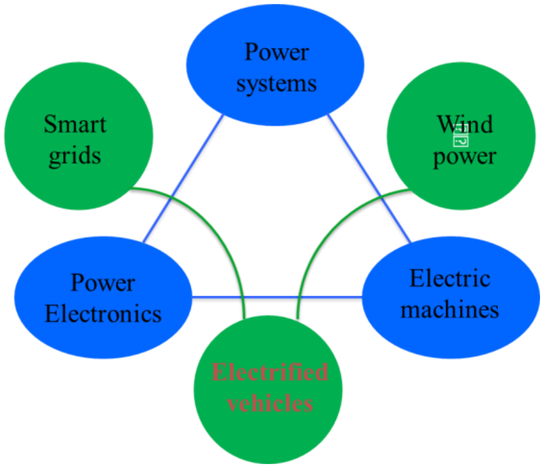
- Aston University
  - Birmingham, UK, B4 7ET



- Power Electronics, Machine and Power System Group
  - Formed in 2009
  - Funding portfolio of more than £5 million
  - 5 academics, 4 post-docs, and 10+ Ph.D. students
  - Four research/teaching labs
- Research Areas
  - Power electronics for power distribution network
    - Renewable energies
    - Energy storage,
    - Smart Grid, such as Electrical vehicles to Grid
  - Electric machines and drives
    - Machine design
    - Machine drives
    - Electrical vehicles



Introduction of Projects

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Overview of RDC2MT project

- Project Title: Research, Demonstration and Commercialisation of DC Microgrid Technologies (RDC2MT)
- Project Facts
  - 48 months project, February 2017 to January 2021
  - Project consortium: 9 different organizations from 5 countries
  - The overall project budget is 436,500 Euros (EU contribution 279,000 Euros)
  - 97 person-months secondments (EU contribution 62 person-months)

- RDC2MT Project Objectives
- Address new challenges of DC Microgrids for building applications
  - Control, communication, optimization
  - Fuel cell CHP, Energy storage
  - DC microgrid Demonstration sites

RDC² MT H2020-MSCA-RISE

Horizon 2020
European Union Funding
for Research & Innovation

Project midterm meeting, June 2018

DC Office and DC green house, Amsterdam (DCBV)

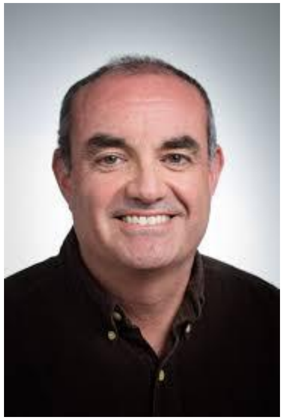
DC building, Xiamen University

- **Dr Zhengyu Lin**
  - RDC2MT project Coordinator
  - Lecturer, Aston University, UK EPSRC Innovation Fellow
  - Email: z.lin@ieee.org
- **Prof. Pavol Bauer**
  - Full professor DC Systems. Energy Conversion & Storage, TU Delft
- **Prof. Xiangning He**
  - Zhejiang University, IEEE Fellow
  - Chinese MOST Match Funding leader
- **Prof. Claudio Cañizares**
  - University of Waterloo, IEEE Fellow

Dr Zhengyu Lin

Prof. Bauer

Prof. He



Prof. Cañizares

Successful Applications of Relevant Funding

- Chinese Ministry of Science and Technology (MOST) match funding
  - Title: The plug and play operation principle and integration application of structured DC microgrids
  - 3 years project (April 2018 to March 2021)
  - 4 Chinese partners, led by Prof. Xiangning He
  - Total budget: 3.95 million RMB (equivalent to 500k+ Euros)
  - **Kick off meeting: 22-23 Nov 2018, Hangzhou, China**

Chinese teams in TU Delft

- UK EPSRC UKRI Innovation Fellowship
  - Dr Zhengyu Lin, Low voltage DC microgrid for cheap and clean energy
    - Three years Fellowship (July 2018 to June 2021)
    - Total budget: £630k (FEC, equivalent to 700k+ Euros)

LVDCMicrogrid.org

EPSRC
Engineering and Physical Sciences Research Council

DC Microgrid Control and Stability

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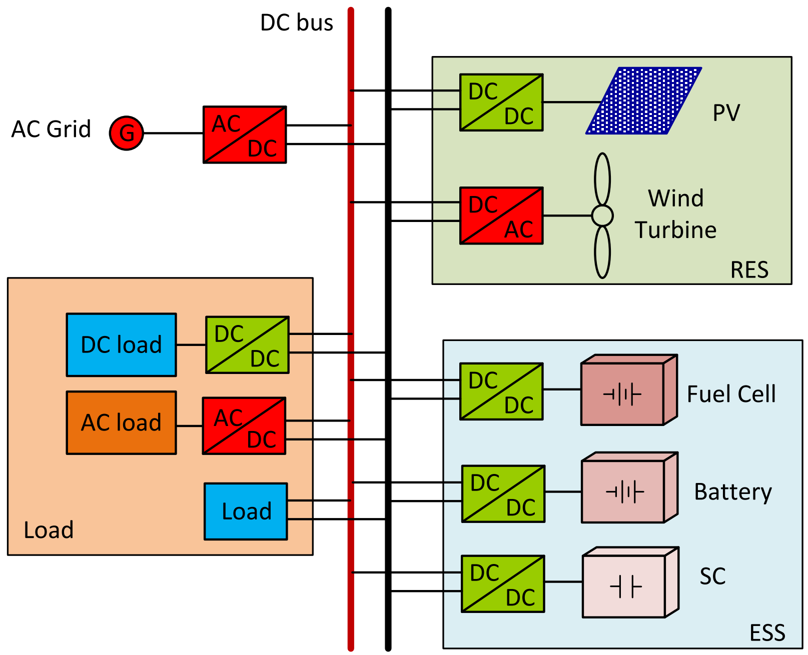
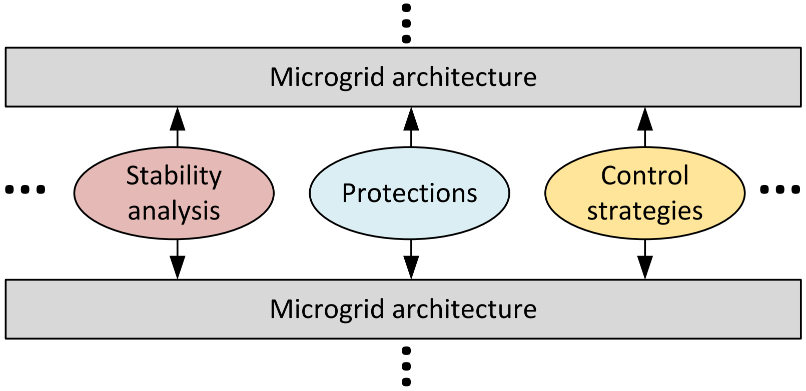
DC Microgrids Overview

- Contains:
  - Distributed sources
    - PV, Wind Turbine, etc.
  - Energy storage
    - Battery, Fuel cell, Supercapacitor, etc.
  - DC load/AC load
    - LED, Electrical Machine, Constant Power Load, etc.

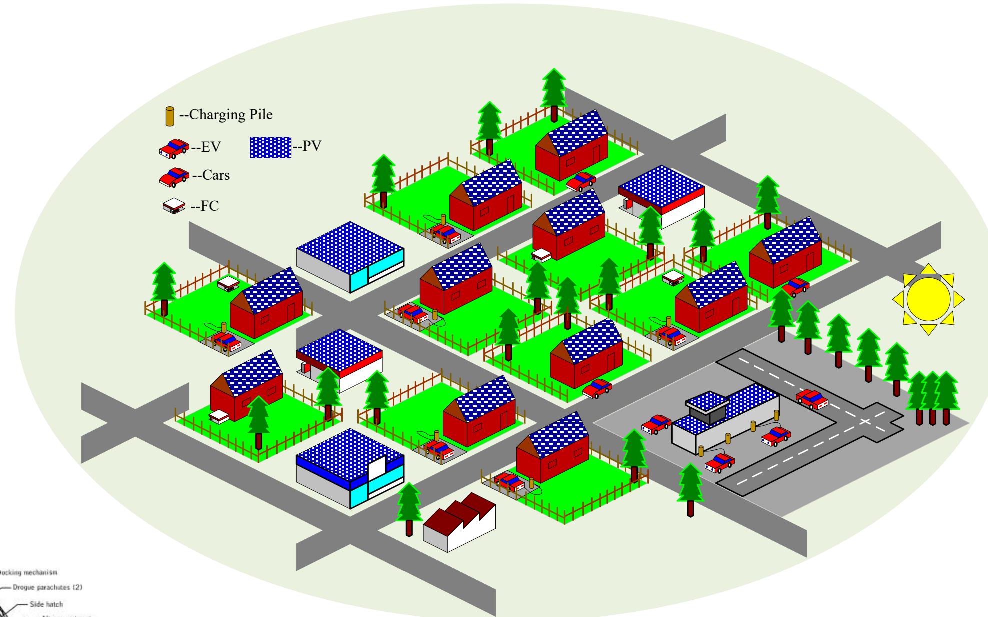


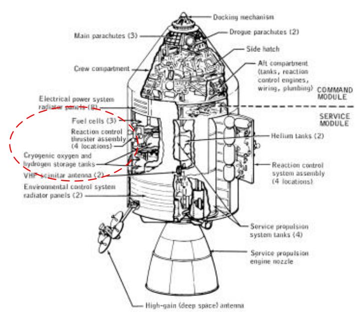
- Topics
  - Control Strategies and Stability Analysis
  - DC Protections and Microgrid Architectures



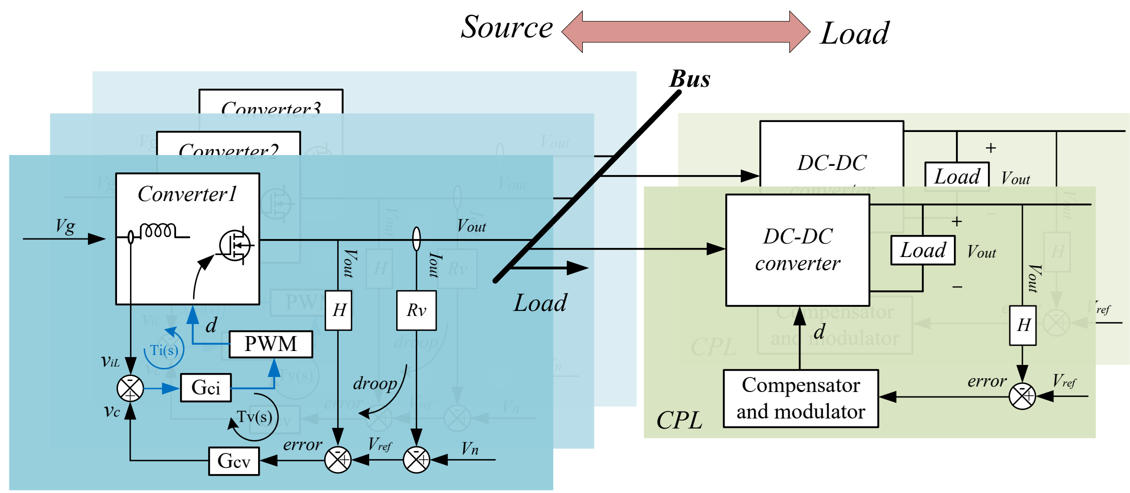
Applications

- Data Centre
- DC Smart House/Community
- Marine/Space Craft/Industrial Robotics

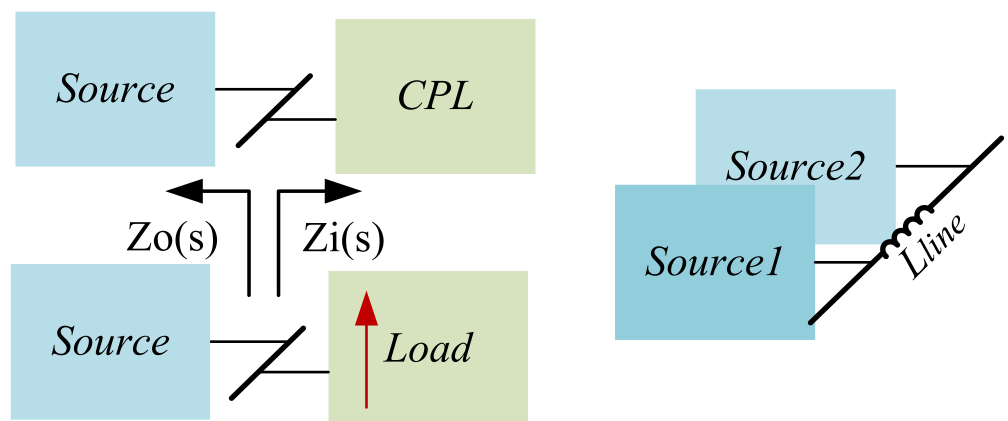




- Why?
  - Necessary for Microgrids Safety Operation
  - Guarantee for Upper Layer Control
- Stability issues:
  - Source to Load
    - Constant Power Load
    - Power Imbalance
  - Source to Source
    - Circulating Current and Bus Voltage Oscillations
  - Introduced by control methods
    - Droop Control Stability

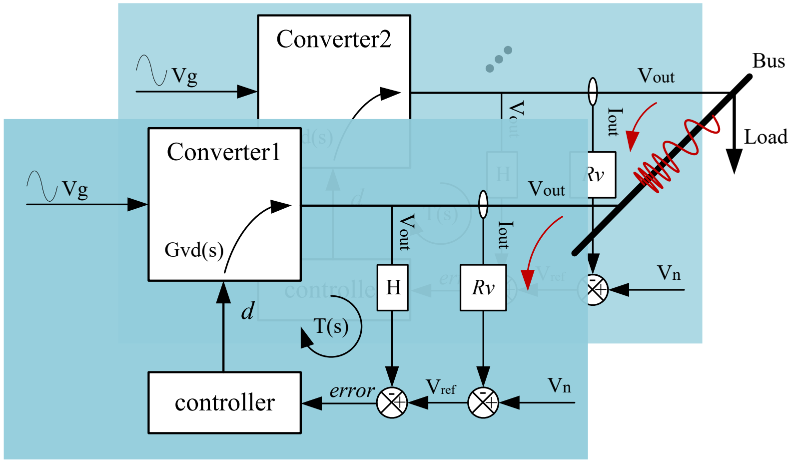


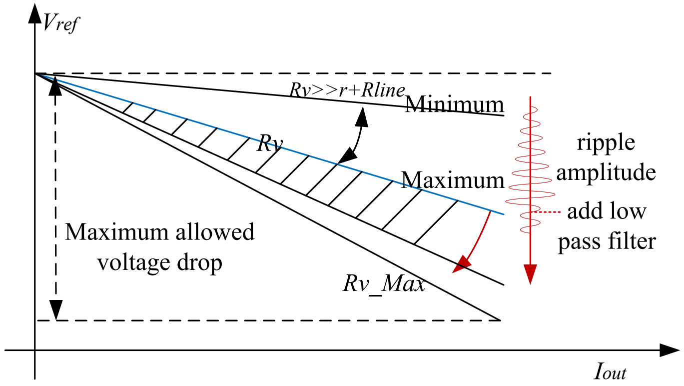
Microgrid control frame

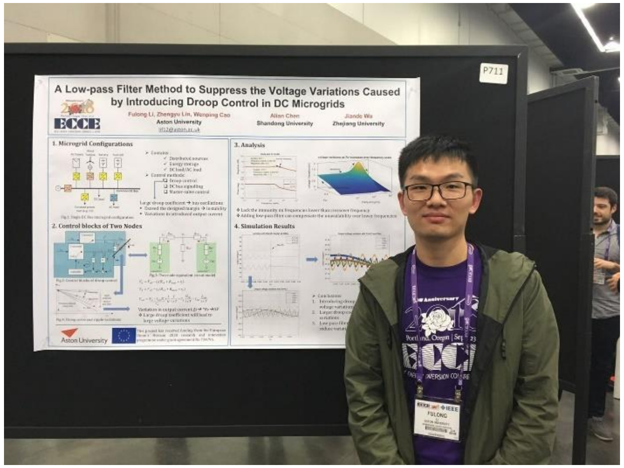


Impact on Stability by Droop Control:

- Large voltage drop → exceed the designed margin
- Introduced output current → control loop lacks the immunity to low frequencies oscillations
  - Large droop coefficient → large voltage variations

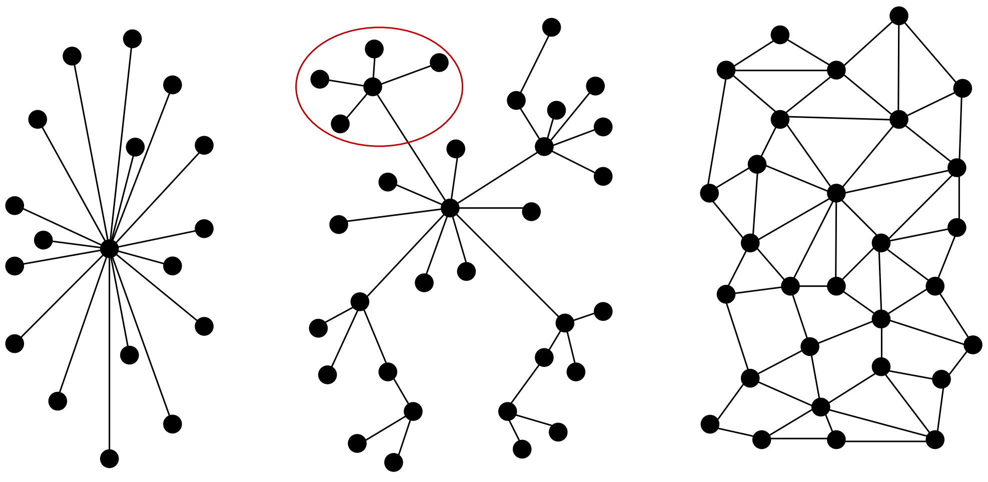




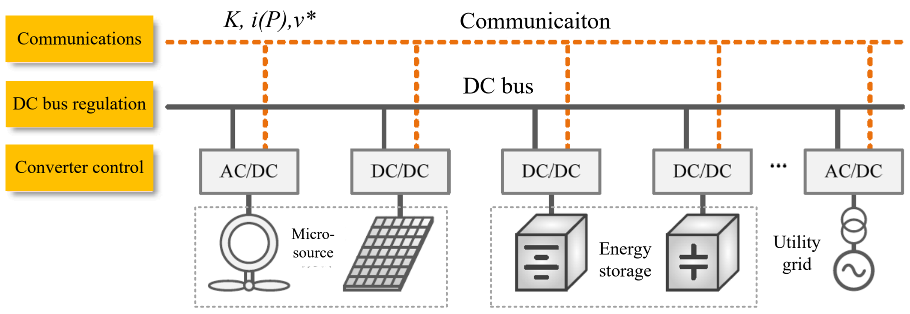


F. Li, Z. Lin, W. Cao, A. Chen and J. Wu, "A Low-pass Filter Method to Suppress the Voltage Variations Caused by Introducing Droop Control in DC Microgrids," *2018 IEEE The Tenth Annual IEEE Energy Conversion Congress and Exposition (ECCE 2018)*, Portland, 2018.

- Control strategies:
  - Centralized Control
    - Communication based control
  - Decentralized Control
    - Non-communication based Master-Slave control
  - Distributed Control
    - Droop control

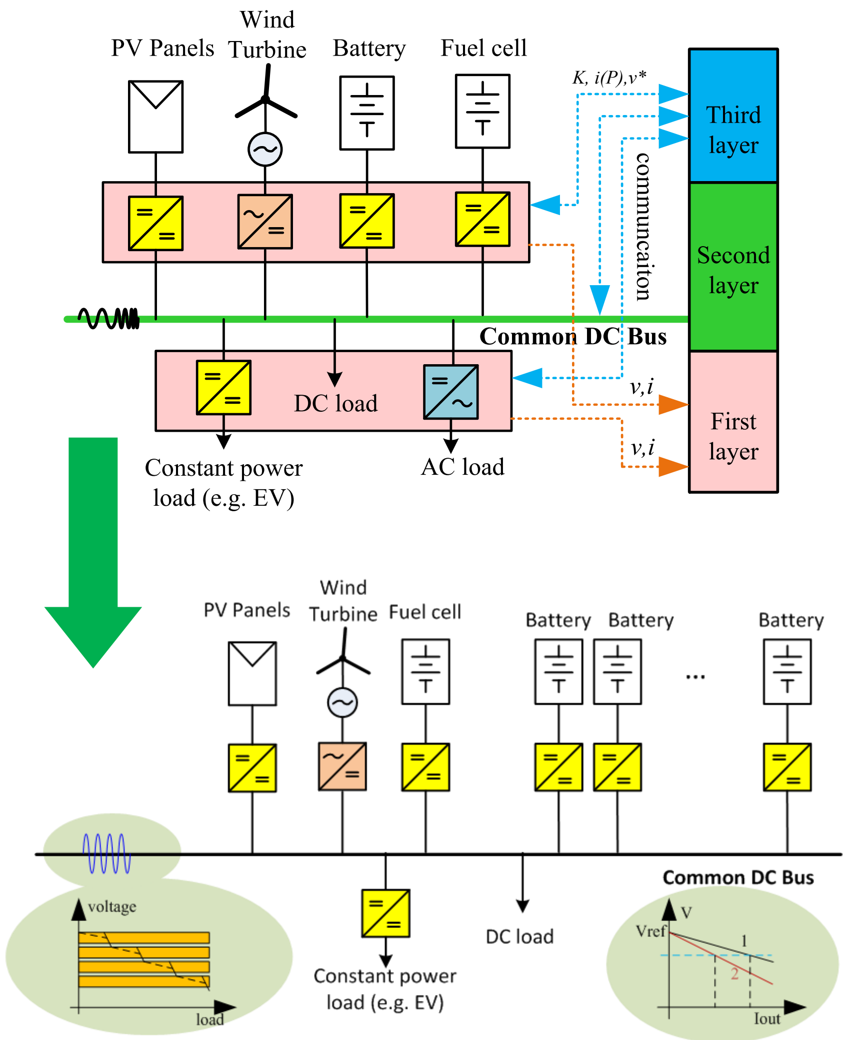


- Hierarchical Control Scheme
  - Primary control
  - Secondary control
  - Tertiary control



Hierarchical Control Scheme

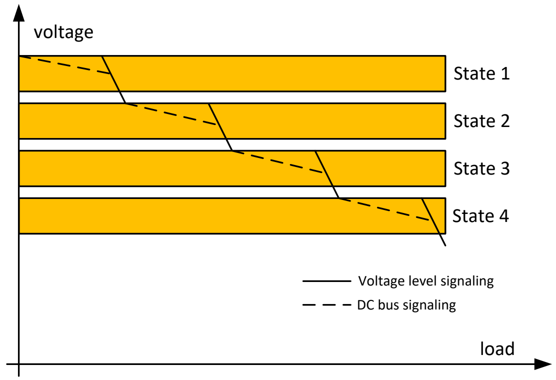
- Primary Control
  - Current/voltage control, droop control
- Secondary Control
  - Bus voltage regulation, such as DC bus signalling, adaptive droop control
- Tertiary Control
  - Communication links, power line communications(non-communication links based)
- Upper layer, etc.

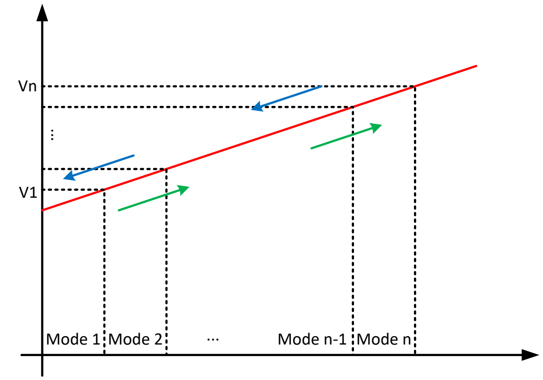


Secondary

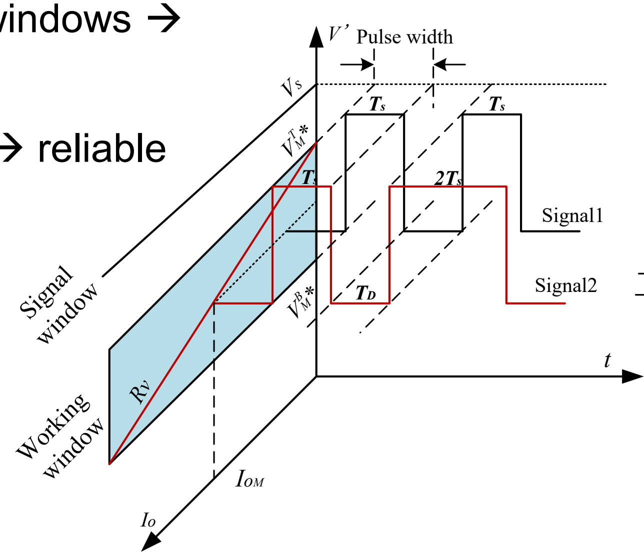
- DC Bus Regulation with Communication Functions

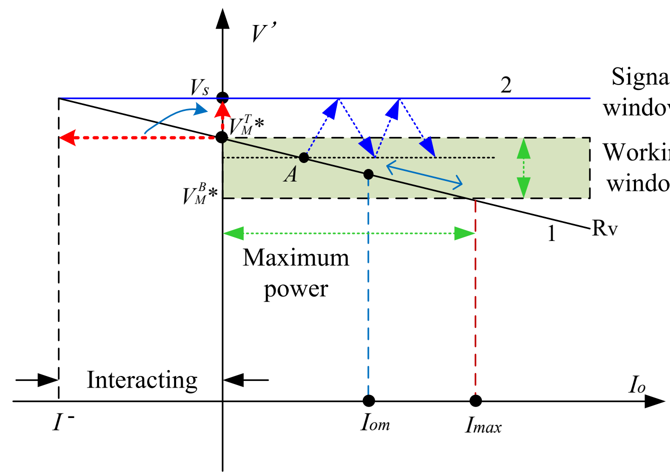
- Secondary control
- Conventional DBS
  - Working voltage windows
  - Load adaptive/orientated





- Active DBS
  - Reduced the voltage windows → enhanced stability
  - Low-speed signalling → reliable power management





F. Li, Z. Lin, Z. Qian and J. Wu, "Active DC bus signaling control method for coordinating multiple energy storage devices in DC microgrid," *2017 IEEE Second International Conference on DC Microgrids (ICDCM)*, Nuremburg, 2017, pp. 221-226.

CORFU 2018

Thank you!
Any questions?

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