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High Dimension Droop Control for Wind Resources in DC Microgrids

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Department of Electrical and
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Introduction & Motivation

This research brings together three important concepts and develops an improved method for implementing them:

Wind Energy: sustainable, renewable source of energy
 • can be distributed geographically and located near loads

Microgrid: subset of larger utility grid

- contains electricity sources, loads, and often storage
- can operate in connection with the utility grid, or in a separate, islanded mode – high system reliability

Droop Control: common method for sharing load between multiple sources in a power system

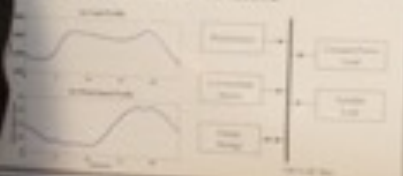
- does not require communication – high control reliability

While droop control has been implemented with wind resources connected with microgrids, traditional droop control does not allow the wind speed to be taken into account – therefore, during times of high wind, available wind power is not utilized.

This research takes the traditional droop control method and expands it to multiple dimensions to allow more of the available power from the wind to be utilized in a dc microgrid.

Approach

In order to study the proposed high dimension droop control method, a simple microgrid was modeled using MATLAB/Simulink. As shown below, typical profiles for the changing load and wind speed over 24 hours were used, to ensure that a realistic situation was modeled.



Control Design

Source modeling: connected through buck converter

- steps down source voltage to bus voltage
- bus state equations

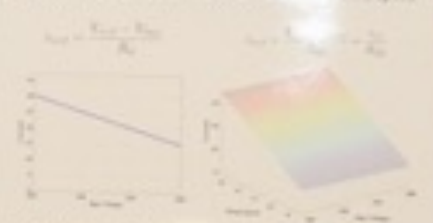


Controller implementation: proportional – integral

$$I_{in} = I_{ref} + K_p (V_b - V_{nom}) + K_i \int (V_b - V_{nom}) dt$$

Droop control: determines reference current

- traditional – line with respect to bus voltage
- proposed – plane with respect to bus voltage and wind speed



Traditional Droop Control High Dimension Droop Control

Method to compare results: cost function

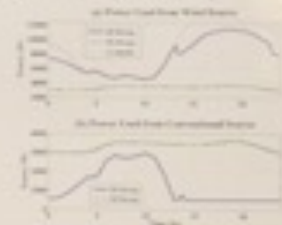
- power – compare power available from the wind to power actually used
- voltage – compare actual bus voltage to nominal value

$$Cost = \alpha \int (P_w - P_{used}) dt + \beta \int (V_b - V_{nom}) dt$$

Simulation Results

Compare simulations:

- traditional droop control (green)
- high dimension droop control (blue)



Control Strategy	Cost
Traditional (2D) Droop	20.48
High Dimension (3D) Droop	2.29

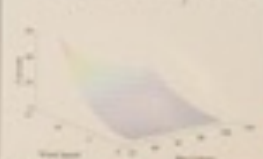
Conclusions and Future Work

Developed high dimension droop control

- tested in simulation using relevant wind and load data
- more of the available wind power is utilized
- advantages of droop control are maintained

Future work:

- optimizing droop surface shape
- example for $Cost = \alpha \int (P_w - P_{used}) dt + \beta \int (V_b - V_{nom}) dt$



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