

American Solar Energy Society

Women in Solar Energy (WISE) Forum

June 25, 2020

Kaitlyn Bunker, Ph.D., P.E.







19



High Dimension Droop Control for Wind Resources in DC Microgrids

Kaitlyn Bunker & Wayne Weaver
Michigan Technological University, Houghton, Michigan
Email: kjbred@mtu.edu, wwwweaver@mtu.edu

Michigan Tech
Michigan Technological University
College of Engineering
Electrical Engineering

Michigan Technological University Graduate Research Colloquium
26 February 2014

Introduction & Motivation
This research brings together those 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, isolated 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 sample microgrid was modeled using MATLAB/Simulink. As shown below typical profiles for the changing load and wind speed over 24 hours were used, to show that a realistic situation was modeled.

Control Design

Source modeling connected through buck converter

- droop down-source voltage to bus voltage
- five state equations

Controller implementation: proportional-integral

$\text{Power} = \text{Nominal Power}$
 $\text{Power} = \text{Nominal Power} + \text{Offset}$
 $\text{Power} = \text{Nominal Power} + \text{Offset} + \text{Feedback}$
 $\text{Power} = \text{Nominal Power} + \text{Offset} + \text{Feedback} + \text{Ramp}$

Droop control: determines reference control

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

Traditional Droop Control

$$\text{Power}_{\text{ref}} = \frac{V_{\text{bus}} - V_{\text{nominal}}}{R_{\text{droop}}}$$

High-Dimension Droop Control

Method to compare results

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

$\text{Error} = \sqrt{\int (P_{\text{wind}} - P_{\text{actual}})^2 dt} + \sqrt{\int (V_{\text{bus}} - V_{\text{nominal}})^2 dt}$

Simulation Results

Compare simulations

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

Control Strategy Cost

Control Strategy	Cost
Traditional (2D) Droop	35.48
High Dimension (3D) Droop	3.29

Conclusions and Future Work

Improved 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 $\text{Control} = \sqrt{\int (P_{\text{wind}} - P_{\text{actual}})^2 dt} + \sqrt{\int (V_{\text{bus}} - V_{\text{nominal}})^2 dt}$

Acknowledgment

This material is based upon work supported by the US National Science Foundation under Grant No. 0940300.

National Science Foundation Logo







