Direct DC-Bus Control for Grid-Forming Converters: Toward the Concept of Dual-Voltage-Forming Converters

Rayane Mourouvin[1], Tuure Nurminen[1], Marko Hinkkanen[1], and Mikko Routimo[2]

[1]Aalto University
[2]ABB Oy Drives

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Abstract

A control method for regulating both dc- and ac-side voltages, based on a disturbance observer, is presented. This method provides a voltage-source behavior from the ac-side perspective, a key functionality of grid-forming converters. A dynamic model is derived to develop the control law using feedback linearization. The control method is able to maintain the dc- and ac-side voltages without any cascaded loops. The method is, therefore, named the dual-voltage forming method to differentiate it from the recent definitions of grid-forming converters. The use of a disturbance observer provides integral action and also inherent synchronization. A transparent current controller is implemented to protect the converter from overcurrents. Small-signal stability of the proposed method is studied analytically and design guidelines are drawn from the analysis. Furthermore, the asymmetric behavior of the converter in different operating modes is analytically assessed. The performance of the method is tested in experimental conditions using a 12.5-kVA test setup. The control method exhibits robust performance in both strong and weak grids in terms of dc-bus voltage reference tracking as well as the capacity to survive large external power variations with power-flow direction changes. Moreover, the effect of a grid voltage sag is studied.

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