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Enhancing wide-area damping controllers via data-assisted power system linear models

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A B S T R A C T

This paper proposes an inter-area oscillation damping control strategy by exploiting the Loewner interpolation method (LIM) and Bellman's principle. The novelty of this methodology lies in providing a data-assisted WADC architecture to damp out interarea oscillations. The architecture is supported by a linear quadratic Gaussian (LQG) controller, based on the Bellman's optimal principle and composed by a linear quadratic regulator (LQR) and a Linear Quadratic Estimator (LQE), which is constituted taking into account a high-fidelity power system linear model derived from the LIM. The control structure is then embedded on a wide-area monitoring system (WAMS) that collects synchrophasor measurements from generation units to conform a wide-area damping control (WADC) system. The proposed scheme exploits the local controllers available in a selected set of generation units regarding the center of inertia (COI) in a power system area. To demonstrate the effectiveness of the proposal, two benchmark power systems: the 2-area Kundur system and the 5-area NETS-NYPS system are simulated including communication delays, wind power plants (WPPs) and HVDC lines. The attained simulation results confirm that a combination of Loewner and LQG-equipped WADC can effectively and timely mitigate inter-area oscillations.

1. Introduction

Low-frequency interarea oscillations reduce the stability and reliability of electrical power systems, since they constrain the power transfer on tie-lines among regions of the power network that contain coherent groups of generators [1–3]. In addition, the increase of distributed generation sources without coordinated control schemes can exacerbate the problem, by increasing the energy exchanges in modern networks. To mitigate these issues, the power system stabilizers (PSSs) have become the traditional solution. PSSs dampen the oscillations, providing a supplementary control actions through the generator excitation systems [4,5].

Nowadays, emergent technologies such as solar [6] and wind power plants [7], HVDC tie-lines [8–10], FACTS devices [11,12], energy storage systems [13] and load modulations [14], have been investigated as alternative control mechanisms to improve the system stability by incorporating sophisticated wide-area damping control (WADC) schemes. In a complementary action scheme, the aforementioned actuators together with both model and data-assisted control methods have been proposed by profiting from state and output feedback controllers. Conventionally, model-based WADC approaches focus on guaranteeing the controllability for a known or identified pair (A,B) [14–17] and synthesizing a mixed H_2/H_∞ output feedback control [18–20]. Meanwhile, data-assisted WADC strategies deal with differential feedback controllers [8,21,22], power system stabilizer-based structures [23], and passivity-based representation [24].

In the literature, several WADC frameworks have been reported, such as: classical control based on phase compensation [25,26], robust control [13,24], adaptive control [27], model-based predictive

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