Cairo microgrid design

Cairo microgrid design

Thank you for visiting nature . You are using a browser version with limited support for CSS. To obtain the best experience, we recommend you use a more up to date browser (or turn off compatibility mode in Internet Explorer). In the meantime, to ensure continued support, we are displaying the site without styles and JavaScript.

Droop control has emerged as a decentralized technique with a key advantage--it does not rely on communication but instead focuses on regional measurements. However, droop control approaches tend to overlook the dynamics of generators, impacting the control response and performance. To guarantee dynamic stability in the presence of a high level of disturbance, consideration and analysis of generator dynamics become imperative8.

Existing literature explores various control strategies such as model predictive control (MPC)9 and modified model predictive control (MMPC)10. However, these approaches often face limitations due to challenges in practical implementation. While MPC and MMPC can offer improved performance in theory, their practical application is hindered by computational complexity and the need for precise modeling, which can be difficult to achieve in real-world scenarios11.

Additionally, Proportional-Integral-Derivative (PID) controllers12,13 and Fractional Order PID (FOPID) controllers14,15 are widely used in practice due to their simplicity and effectiveness in many applications. However, these controllers also have limitations. PID controllers can struggle with system uncertainties and non-linearities16, leading to suboptimal performance under certain conditions. FOPID controllers, while offering better tuning flexibility and robustness than traditional PID controllers, still face challenges related to parameter tuning and implementation complexity17.

Thus, while these control strategies are extensively employed in practice, their limitations, including system uncertainties, lack of a systematic framework, and practical implementation challenges, must be acknowledged and addressed to enhance their effectiveness in ensuring dynamic stability and optimal performance.

In summary, the research gap addressed by this paper is the need for a decentralized control strategy that can effectively manage frequency deviations in isolated microgrids while considering practical implementation challenges such as controller order and weight filter design. By leveraging the robustness and systematic design framework of m-synthesis, this paper contributes a viable solution to enhance the stability and performance of isolated microgrids, outperforming other control strategies that struggle with system uncertainties and practical implementation issues.

This work builds upon recent studies, contributing a comprehensive approach that not only embraces low-order implementation but also considers uncertainties and integrates weight filters for improved control sensitivity and system performance.

Recent developments in the field include studies on decentralized low-order m-synthesis controllers in22, which, although practically implemented with a low order, did not delve into the consideration of weight filters. Additionally, investigations in23,24 addressed m-synthesis controllers in decentralized settings but focused primarily on system order considerations rather than practical implementation aspects. Another noteworthy study proposed an eighth-order m-synthesis controller in25 with only 20% structure uncertainty, emphasizing the need for a lower-order controller for practical implementation. Other studies in26,27 suggested H? controllers but with the same system order and without weight filter consideration.

Figure1 depicts the configured architecture of an isolated hybrid microgrid under examination. The microgrid ensemble encompasses a suite of energy sources, including a diesel generator, fuel cell, electrolyzer, wind generation system, and an ultra-capacitor serving as an energy storage system28,29. The diesel generator is supplied with a speed governor, which functions to regulate the speed of the diesel engine. Concurrently, a blade pitch control mechanism is employed within the wind turbine system to ensure that the speed of the wind turbine generator remains within prescribed operating limits, preventing it from surpassing the designated maximum power set point amidst fluctuating wind speeds29.

Microgrid configuration.

According to Eq.(1), the intermittent characteristics inherent in a renewable wind generation system can influence the power quality and overall performance of a hybrid microgrid. To mitigate potential disruptions, the blade pitch control methodology is implemented to minimize errors in power generation and mitigate frequency variations. The continuous monitoring of wind turbine speed is facilitated by the blade pitch control mechanism, which actively engages within the turbine"s feedback control system, ensuring precise and responsive adjustments.

In practice, several ultra-capacitors are connected together to achieve the required terminal voltage and energy storage capacity.