Ph.D. title: Fault Tolerance Optimal Operation of Droop-Based Microgrids
Student: Pedro Pablo Vergara Barrios

Abstract: As we move to a more complex electrical distribution system, as a result of the increasing deployment of distributed generation and storage units, many new operational challenges have appeared. In the technical literature, one of the most accepted solution to deal with these operational challenges is the standard hierarchical control framework. This framework comprises multiple control layers to deal simultaneously with the slowest dynamic associated with the dispatch decisions (high-level layer), and with the fastest dynamic associated with the local control architecture (lower-level layer). Based on this, this thesis focuses on the higher-level layer, presenting new and sophisticated mathematical models to deal with the dispatch problem of an islanded microgrid. The microgrid is composed of different distributed generation (DG) units, including renewable-based units, and battery systems (BSs). The main contribution of these models is related to the modeling of the lower-layer control, implemented using droop control. Moreover, as these mathematical formulations are generally difficult to solve, this thesis also introduces new approximation procedures that simplify the original formulations, allowing the use of commercial solvers.

Although the hierarchical control framework has been accepted as the standard solution, this might not be suitable for large-scale systems. In this sense, a new trend in the research community has recently been established, focused on distributed control frameworks. These frameworks offer attractive features such as fault-tolerance, scalability, plug-and-play, robustness, among others. Considering this, a control strategy to operate a microgrid in a distributed fashion is also presented in this thesis. This work has overcome two important drawbacks found in the technical literature: Firstly, the active and reactive power balance is continuously corrected, even during the execution of the control strategy; and secondly, the strategy is considered to operate with a distributed version of the hierarchical control framework.

On the other hand, as the operation of the microgrid is essentially different in grid-connected (GC) and islanded (IS) mode, a new and generalized mathematical model is also presented. This model allows the microgrid's operator to plan in advance the operational mode that guarantee a safe operation. Additionally, a new set of convexification procedures are also introduced, in order to solve the proposed formulation using commercial solvers.

Finally, due to the uncertain operational environment of the renewable-based generation and the consumption, deterministic dispatch approaches might fail to ensure a secure operation. To deal with this, a scenario-based stochastic model for the operation problem of an islanded microgrid is presented. The impact of the level of uncertainty in the data is assessed in the optimal dispatch solution.

Keywords: Microgrids; islanded operation; droop control, optimal power flow, optimal dispatch.