Dynamic voltage restorer controlled per independent phases for power quality sags-swells mitigation under unbalanced conditions

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10.1 Introduction

The most common power quality issues are associated with voltage variations, being known as sags and swells. Voltage variations are triggered by the incorporation of a large amount of power electronic converters that interface distributed energy resources, such as solar and wind. Voltage sags are generated by faults, or unsuitable starting of electromechanical machines, such as motors and transformers, whereas voltage swells are provoked by switching of protecting devices and connection of capacitor banks. Large voltage excursions under unbalanced conditions cause critical events in sensitive loads [1]. These are harmful for industrial, commercial, and residential loads [2,3]. To mitigate these issues, grid codes establish a maximum admissible limits for voltage variations, which must be fulfilled according to the IEC std. 61000-4-30 [4] and the IEEE/ANSI Std. 519 [5].

To solve the voltage variations by using dynamic voltage restorers (DVRs), two approaches have been proposed: artificial intelligence (AI) and traditional linear/nonlinear control structures. The former has recently been explored in combination with nonlinear control techniques for DVRs, using techniques such as machine learning (ML) and deep learning (DL) [6]. Different investigations report the application of AI in nonlinear controllers with ML, controllers based on neural networks [7–9], and controllers with fuzzy logic [10–12]. The latter implement known control structures with topological changes, such as a DVR with automatic balancing of the capacitor voltage [13], a transformerless DVR with predictive controller [14], a DVR with a novel method for detecting sags in less than 2 ms [15], an energy storage system-based DVR that uses a precompensation method for the voltage amplitude in three-phase systems [16], a sliding mode-based control strategy for a 3-phase DVR employing a 12-switch voltage source converter [17], among others [18,19]. Despite their advantages, all of these works present complex control algorithms that are unable to operate in unbal-

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