Energies, vol.11, no.8, pp.1972-1-1972-26, August, 2018.

Comprehensive design and analysis of a state-feedback controller for a dynamic voltage restorer

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Abstract-

Voltage sags result in unwanted operation stops and large economical losses in industrial applications. A dynamic voltage restorer (DVR) is a power-electronics-based device conceived to protect high-power installations against these events. However, the design of a DVR control system is not straightforward and it has some peculiarities. First of all, a DVR includes a resonant (LC) connection filter with a lightly damped resonance. Secondly, the control system of a DVR should work properly regardless of the type of load, which can be linear or non-linear, to be protected. In this paper, a digital state-feedback (SF) controller for a DVR is proposed to address these issues. The design and features of the SF controller are studied in detail. Two pole-placement alternatives are discussed and the system robustness is tested under variations in the system parameters. Furthermore, implementation aspects such as discretization not commonly addressed in the literature are described. The controller is implemented in its incremental form. A decoupling system for the dq-axis dynamics that takes into account system delays and the load current is proposed and analytically studied. The proposed controller is compared with two other alternatives found in the literature: a Proportional-Integral-Differential (PID) controller and a cascade controller. The effect of the load connected downstream a DVR is also studied, revealing the potential of the SF controller to damp the resonance under light load conditions. All control system developments were tested in a 5 kVA prototype of a DVR connected to a configurable grid.

Index Terms- AC-DC power converters; dynamic voltage restorer (DVR); voltage sags; state-feedback controller; discrete-time control systems

Citation:
Roldán-Pérez, J.; García-Cerrada, A.; Rodriguez-Cabero, A.; Zamora, J. "Comprehensive design and analysis of a state-feedback controller for a dynamic voltage restorer", Energies, vol.11, no.8, pp.1972-1-1972-26, August, 2018.