

# Voltage and Reactive Power Regulation by Photovoltaics in Distribution Systems

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## ABSTRACT

This research focuses on the design and implementation of two novel controllers within rooftop photovoltaic (PV) inverters. The main objective of the first control scheme is to eliminate the voltage violation (induced voltage rise due to reverse power flow) and to maintain the voltages within acceptable bounds, at essentially no extra investment cost to the PV owner. The second controller can significantly reduce real energy losses in the distribution feeder and reactive energy demand at the substation. Besides, reducing reactive demand at substation leads to loss reduction of substation transformer and transmission network. It can also relieve congestion in transmission network and improve the voltage stability. A significant advantage of the proposed controllers is that they do not require communication or cooperation with other PV inverters. The control objectives are attained by exploiting the inherent reactive power capability of the inverters and the dispatch of their reactive power is calculated in an autonomous fashion. In this context, important theoretical aspects of control design are investigated and a general framework for stability analysis of these types of systems is established. In addition, this work reports on the development of a distribution test feeder with smart-grid functionality. The test feeder is based on an actual distribution feeder. Case studies involving simulations of real (the developed feeder) and realistic distribution feeders with hundreds of households and their appliances modeled in high detail are performed to study the impacts of the proposed controllers on the distribution system. It is shown that implementation of these controllers could have a significant beneficial impact upon the efficiency and operation of the power grid.