

# Fuzzy based Dynamic Stability Enhancing Control Strategy for power systems with High-Level PV Penetration

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**Abstract:** *The deregulated power system has paved the way for a significant number of distributed energy resources (DER). This results in a large installation of renewable sources in the grid. Thus large installations of PV systems are becoming more common. These Centralized PV systems can cause major issues in the existing grid if these are not adequately addressed. The significant contribution of these systems can cause problems with the dynamic stability of the power system. The intermittent and inertia-less nature of PV systems can produce significant power oscillations. At the present condition, the penetration level of PV into the grid is limited by the utilities, to prevent problems of power oscillation. Thus the PV plant capacity cannot be increased beyond the penetration limit. The penetration limit depends on several factors such as the types of loads and stability enhancement devices on the grid. The penetration limit is regulated cyclically. This paper proposes a Fuzzy control strategy for power oscillation damping in power systems implemented in Grid connected converters (GCC) so that the power system stability is enhanced without any additional cost of equipment. This, in turn, helps to provide a penetration margin and thereby to increase the PV capacity of the grid.*

**Keywords -** *Distributed Generation (DG), Grid connected Converter (GCC), PV penetration, Point of Common Coupling (PCC), Power Oscillation Damping (POD), Structure Preserving Energy Functions (SPEF)*

## I. Introduction

The global energy demand is increasing every year, to meet the future demand more energy resources are required. The International Energy Agency (IEA) says the world's energy needs could be 50% higher in 2030 than they are today [1]. The security of global energy supplies continues to be problematic. Today, oil and gas reserves are in the hands of a small group of nations, several of which are considered political unstable or have testy relationships with large consuming countries [2]. In 2010, the total renewable energy capacity was only 5% of the total capacity, but as of now, we have about 18% of renewable capacity [1]. Among the renewable source of energy, the most prominent are the PV systems; the declining prices of solar panels coupled with government incentives have made solar PV systems much favorable among other sources of renewable energy. In 2010, among world's total installed power capacity, the contribution of PV systems was less than 5%. In the new policy scenario, power generated from PV systems is expected to be 600 GW as of 2035. Moreover, now we have centralized PV plants of large capacities such as the 648 MWp plant in Tamil Nadu & 12 MWp in Kerala, resulting in a significant amount of PV penetration into the grid. The existing grids were designed for systems with powerhouses at one end & the load at the other. The integration of several renewables has caused several detrimental effects on the grid. Besides the power quality & protection issues, one of biggest concern is the system stability. The PV-DG systems are inertia-less systems, integration of such systems into the grid can result in reduced system inertia and thereby affecting the transient system stability. Several studies [3]-[6] has concluded that the system stability is compromised during high PV penetration. During high PV

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