

Abstract

Robust Nonlinear Control and Maximum Power Point Tracking in PV Solar Energy System under Real Environmental Conditions [†]

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Abstract: The optimization of the operational performance of PV systems requires tracking the PV operating point at which maximum power is available. Given that, in practice, the PV system is subjected to environmental parameters, which are random, the continuous tracking of this point, the maximum power point (MPP), becomes an absolute necessity. Numerous techniques for maximum power point tracking (MPPT) have been reported in the literature. However, these techniques suffer from numerous problems, such as oscillation around the maximum power point and robust inabilities. Taking into account the nonlinear nature of the PV coupled to the nonlinear time-variant nature of power electronic converters interfaced in PV systems, nonlinear control is a vital strategy to guarantee both an oscillation free and a robust PV-MPPT system. This work presents a nonlinear robust strategy for the MPPT control of the PV system using a Boost DC-DC converter. The nonlinear strategy is based on the integral backstepping controller. The control system uses a trained artificial neural network (ANN) to generate a reference voltage that is injected into the closed system for reference tracking. The stability of the closed system has been verified using Lyapunov functions. To ensure the effective and robust response of the closed loop system, mathematical equations derived by initializing tuning goals in the control law have been developed. Therefore, the closed-loop system forms a robust integral backstepping (RIBS) control. The performance of the RIBS-MPPT system has been investigated in real environmental conditions under the light as well as heavy load variations, which are perceived by the nonlinear controller as disturbances, while its performance has been benchmarked against the conventional perturb and observed (P&O). It was noted that the RIBS outperformed the P&O under all test conditions. An interesting feature of the proposed RIBS lies in its high reference tracking and zero steady-state oscillations potential under heavy disturbances in real environmental conditions. Therefore, the proposed nonlinear control scheme is suitable for the effective and efficient optimization of PV systems.

Keywords: MPPT; ANN; robust integral backstepping (RIBS); perturb and observed (P&O); PV systems



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