Centralized Controller for Photovoltaic MPPT, Bidirectional Charging, and Dynamic Load Control Using Deep Reinforcement Learning

Abstract

This work proposes a centralized controller operating using Deep Reinforcement Learning (RL) for a small-scale Photovoltaic (PV), Battery Energy Storage System (BESS) Distributed Energy Resource system. The RL agent was trained using the Proximal-Policy Optimization (PPO) algorithm for Maximum Power Point Tracking (MPPT), charging/discharging of a BESS, and controlling the output voltage at the load. The RL agent was compared with alternative methods of control, such as the Perturb and Observe (P&O) algorithm, and Proportional-Integral (PI) methods. The RL agent was tested in the system which utilized two 100 W Solar Panels that experienced random solar irradiance, and a 12 V 100 Ah BESS used to supply power to Dynamic Loads of 100 W with a lagging power factor of 0.8. The agent outperformed the alternative methods for MPPT, charging/discharging the BESS, controlling the output voltage to the desired value, and reducing the Total Harmonic Distortions to 0.23% from 1.70%.

Keywords— Distributed Energy Resources, MPPT, Bidirectional Charging, MATLAB Simulink, Deep Reinforcement Learning