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Predictive Maximum Power Point Tracking for Proton Exchange Membrane Fuel Cell System

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ABSTRACT This project aims to design a predictive maximum power point tracking (MPPT) for a proton exchange membrane fuel cell system (PEMFC). This predictive MPPT includes the predictive control algorithm of a DC-DC boost converter in the fully functional mathematical modeling of the PEMFC system. The DC-DC boost converter is controlled by the MPPT algorithm and regulates the voltage of the PEMFC to extract the maximum output power. All simulations were performed using MATLAB software to show the power characteristics extracted from the PEMFC system. As a result, the newly designed predictive MPPT algorithm has a fast-tracking of maximum power point (MPP) for different fuel cell (FC) parameters. It is confirmed that the proposed MPPT technique exhibits fast tracking of the MPP locus, outstanding accuracy, and robustness with respect to environmental changes. Furthermore, its MPP tracking time is at least five times faster than that of the particle swarm optimizer with the proportional-integral-derivative controller method.

INDEX TERMS MATLAB, FC, PEMFC, DC-DC boost converter, MPPT

I. INTRODUCTION

It is well known that the Earth suffers from the depletion of fossil fuels [1]. Thus, there is an urgent need to identify alternative energy sources. Fuel cells (FC) are renewable energy sources that are emerging to deliver clean and efficient power. Its power efficiency can reach 45%, which is higher than that of common electricity generation [2]. Fuel cells can generate electrical power ranging from portable kilowatts to multimegawatt stationary power plants [3]. This technology is applied to residential, commercial, and industrial applications. Therefore, fuel cells can be considered as the top of the desirable technologies for a broad spectrum of power generation applications. This is because it exhibits high efficiency, negligible environmental emissions, and is non-site specific.

Among the fuel cell technologies, proton exchange membrane fuel cells (PEMFCs) have been intensively studied. PEMFCs are the most popular fuel cell types, which use hydrogen gas as fuel. It converts hydrogen and oxygen from chemical to electrical energy. An interesting feature of PEMFCs is their high power density, fast start-up, and low operating temperature [4]. Therefore, it can be used in diverse applications for terrestrial vehicles and rural power plants, but fuel cells require a large investment.

Despite the relatively high efficiency of the fuel cell, the power extracted from the fuel cell is not always optimal because of the ever-changing internal variables [1]. A maximum power point tracking (MPPT) algorithm is required via the power electronics interface to ensure maximum power extraction. The proposed MPPT algorithm modulates the DC-DC power converter to extract the maximum power from the system and guarantee optimal resource usage [5].

II. LITERATURE REVIEW

There are various techniques for MPPT in the literature such as, Perturb and Observe (P&O), Incremental Conductance (IC), Extremum Seeking Control (ESC), Sliding Mode Control (SMC), Fuzzy Logic Control (FLC), Particle Swarm Optimizer (PSO), Radial Basis Function Network (RBFN), and as well, Salp Swarm Algorithm (SSA) methods. The MPPT algorithm has been widely applied to solar photovoltaic (PV) systems to obtain the maximum output power from a PV