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Differential Flatness Using the Predictive Neural Network Control Law for Hybrid Power System

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Abstract- In this paper, a control design for a renewable energy hybrid power system that is fed by a photovoltaic (PV), Wind turbine (WT) and fuel cell (FC) sources with a battery (Batt) storage device is presented. The energy generated is managed through a nonlinear approach based on the differential flatness property. The control technique used in this work permits the entire description of the state's trajectories, and so to improve the dynamic response, stability and robustness of the proposed hybrid system by decreasing the static error in the output regulated voltage. The control law of this approach is improved using the predictive neural network (PNN) to ensure a better tracking for the reference trajectory signals. The obtained results show that the proposed flatness-PNN is able to manage well the power flow in a hybrid system with multi-renewable sources, providing more stability by decreasing the perturbation in the controlled DC bus voltage.

Keywords: Control; renewable energy; hybrid system; photovoltaic; Wind turbine; fuel cell; battery; flatness systems; neural network; energy management.

1. Introduction

Nowadays, the renewable power generation systems are expected to be increasingly used in different applications. The solar and the wind can be considered as effective and harmless energy sources; however, there are still some serious disquiets about these renewable energy sources and their employment. The solar and wind energies cannot produce power progressively, since its power production rates change with periods, months, days and hours. So the common disadvantage among these systems is their intermittent nature and dependence on weather changes. Therefore, such systems can be equipped with fuel cells as a secondary generation source and batteries bank devices for the storage reasons and to meet the requirement load demand during the system's lifetime. Usually, hybrid systems which contain more than one generation source can be considered as efficient systems, often two or more renewable energy sources are required to ensure a reliable and cost effective power [1].

A combination of PV, WT and FC sources forms a good production power system with promising features for distributed generation applications. Of course, the slow response of the FC [2] needs to be compensated with a storage system such as batteries or supercapacitors. A battery storage has been chosen in this work due to economic reasons.

Recently, an investigation of the literature has revealed that numerous researches have been performed for modelling with linear or nonlinear control features and in the various engineering disciplines for example; the control structure in micro grids with distributed generation: Island and grid-connected mode in [3], predictive control of the solid oxide fuel cell stack temperature with models based on experimental data [4]; control of electric power distributed generation systems for micro grid applications has been studied in [5], control of a mobile manipulator actuated by DC Motors in [6] and control of PEM fuel cell system via higher order sliding mode control in [7].