SENSORLESS FUZZY LOGIC CONTROLLER (FLC) BASED MAXIMUM POWER POINT TRACKING (MPPT) ALGORITHM FOR HYDROKINETIC ENERGY HARNESSING

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Abstract

This paper presents a sensor-less control strategy based on the Fuzzy Logic Controller (FLC) Maximum Power Point Tracking Algorithm (MPPT) for stand-alone hydrokinetic energy harnessing in the river. The FLC MPPT algorithm was proposed due to the variation of the water velocity and the weakness of the conventional MPPT algorithm, such as the Perturb and Observe (P&O) MPPT algorithm under highly nonlinear water velocity. The hydrokinetic comprises a water turbine, permanent magnet synchronous generator (PMSG), passive rectifier, and DC boost converter. In this work, MATLAB/Simulink has been implemented to design the circuit topology for hydrokinetic technology. Then, the modeling of the complete system has been simulated under the different speeds of water velocities. The proposed FLC MPPT has been compared to the conventional P&O MPPT algorithm regarding power efficiency and tracking response time. The results show that the proposed FLC MPPT algorithm achieved an average 93 % efficiency in extracting the output power and a 35.49 % faster response time than the P&O MPPT algorithm.

1 Introduction

Renewable energy is extracted from assets recharged naturally on a human scale, such as sunlight, wind, rain, oceans, tides, and geothermal heat [1]. Every year, the utilization of green energies as a safe and long-term source of electricity is developing quickly and is anticipated to grow universally. This is due to fossil fuel depletion and environmental issues, such as carbon dioxide (CO_2) emissions and greenhouse effects[2]. Hydrokinetics energy harnessing has also been studied as a potential for renewable energy resources for stand-alone and remote communities [3]. This energy resource could be an alternative to solar photovoltaic, wind, biomass, and geothermal energy to provide clean, safe, and sustainable energy for future generations.

Hydrokinetic technology has many benefits, such as producing energy without the need for any dam or other infrastructure and giving the environment minimal effect [4]. This energy-harnessing method can be used on ponds, artificial waterways, and other streaming structures with the proper water speed [5]. With the world's thousands of miles of rivers, this could be a viable, sustainable power innovation for increasing current hydrokinetic capability.

To extract more power from the hydrokinetic system while maintaining the optimal output power, it can be equipped with the MPPT algorithm. Furthermore, the variation of river water velocity is a significant problem, particularly in designing a control system capable of harnessing full output power while maintaining high performance.

Hydrokinetic technology's concept, operation, and hardware components are similar to the wind energy system (WECS). Thus, the MPPT algorithm based on WECS is the main source for particular research in hydrokinetics. To date, various methods of MPPT algorithm have been proposed by researchers in the literature, such as an adaptive MPPT [6], [7], hybrid MPPT[8], [9], optimization-based MPPT [10], [11] and Fuzzy based MPPT [12]–[19].

Judging from the literature review, the MPPT algorithm in WECS is emerging tremendously with the latest MPPT techniques, such as adaptive and hybrid. Nevertheless, the implementation of the MPPT algorithm in hydrokinetics is scarce and limited in the literature. Nonetheless, some researchers have published the conventional MPPT algorithm in hydrokinetic technology, such as in [20][21].

In this paper, the sensor-less FLC MPPT algorithm for stand-alone hydrokinetic energy harnessing in the river has been proposed. The design topology for the hydrokinetic technology comprises a water turbine, permanent magnet synchronous generator (PMSG), passive rectifier, and DC boost converter that has been modelled and simulated using the MATLAB/Simulink.