HILL-CLIMBING SEARCH (HCS) MPPT ALGORITHM FOR HYDROKINETIC ENERGY HARNESSING

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Abstract

Hydrokinetic turbines based on rivers are environmentally friendly technology that has increased interest in advanced scientific research during the last decade. The kinetic energy formed from the water stream can be harnessed as long as the water is flowing. Nevertheless, the variation and fluctuation of water current speed and turbulence flow in a river is the main issue, especially in designing a control system that can harness the maximum output with high efficiency. Various methods and techniques have been applied in hydrokinetic energy conversion systems to extract maximum power. This paper presents the performance of the Hill Climbing Search (HCS) MPPT Algorithm in hydrokinetic energy harnessing in terms of steady-state oscillation, time tracking, and efficiency. The model of hydrokinetic energy harnessing is developed using MATLAB/Simulink that comprises a water turbine, permanent magnet synchronous generator (PMSG), passive rectifier, and DC boost converter. The MPPT algorithm can be employed in the DC boost converter by regulating the ratio of the duty cycle. The results show the HCS MPPT algorithm reduced the steady-state oscillation, rapid time tracking and improved 93.75% of efficiency.

1 Introduction

Hydrokinetic is a form of energy from the flowing water from the earth's tides, waves, ocean currents, and rivers [1]. Energy harnessing from hydrokinetic required enough speed and velocity of water to ensure the turbine could generate electricity consistently. Nevertheless, climate change and geographical structure will affect the water velocity profile. Furthermore, the fluctuation and turbulence flow of water current speed in a river is a problematic task, especially when it comes to develop a control system that can efficiently harness maximum output power [2].

A different method of MPPT algorithm has been proposed by several researchers to extract the maximum power in the hydrokinetic energy harnessing such in [2] – [10]. In [3], [4] the P&O MPPT algorithm is employed in the DC converter to obtain the maximum energy from the hydrokinetic turbine. In [2], the Modified HCS-PI MPPT algorithm is suggested, and based on simulation results, the energy extraction is improved with 96.32 % of efficiency. In [5] an adaptive step size based on the P&O algorithm is applied to control the fixed pitch hydrokinetic turbine.

Control strategies such as Power Prediction Method [6], Rule-based control strategy [7], and Flatness-based control [8] have been implemented on the hydrokinetic energy harnessing with an aim to improve the turbine design, produce reliable output power during uncertainty load and maintain the generator's frequency during water fluctuations respectively. While in [10] robust gain scheduled control is proposed to regulate the output power during high-rated water velocities. In this paper, the HCS MPPT algorithm is implemented for the hydrokinetic energy harnessing to investigate the steady-state oscillation at the output power, system efficiency, and tracking accuracy under variation of water flow.

2. Hydrokinetic Energy Conversion System (HECS)

2.1 Turbine configuration

Small or medium-sized turbines aligned with the stream can be employed in these situations to convert the kinetic energy available in river cross sections, as shown in Fig. 1. Axial flow turbines and crossflow turbines are the two types of hydrokinetic turbines available. As indicated in Fig. 2, turbines are categorised depending on the rotor's axis of orientation with regard to the flow direction. Nevertheless, a vertical axis turbine is commonly applied in the river due to its ability to accept any direction of water flow [12].