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# A Rule-Based Phase Control Methodology for a Slider-Crank Wave Energy Converter Power Take-Off System

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**Abstract:** The slider crank is a proven mechanical linkage system with a long history of successful applications, and the slider-crank ocean wave energy converter (WEC) is a type of WEC that converts linear motion into rotation. This paper presents a control algorithm for a slider-crank WEC. In this study, a time-domain hydrodynamic analysis is adopted, and an AC synchronous machine is used in the power take-off (PTO) system to achieve relatively high system performance. Also, a rule-based phase control strategy is applied to maximize energy extraction, making the system suitable for not only regular sinusoidal waves but also irregular waves. Simulations are carried out under regular sinusoidal wave and synthetically produced irregular wave conditions; performance validations are also presented with high-precision, real ocean wave surface elevation data. The influences of significant wave height, peak period, the moment of inertia of the PTO system, and the gear ratio of the system upon energy extraction of the system are studied. Energy extraction results using the proposed method are compared to those of the passive loading and complex conjugate control strategies; results show that the level of energy extraction is between those of the passive loading and complex conjugate control strategies, and the suboptimal nature of this control strategy is verified.

**Keywords:** ocean energy; rule-based control; slider crank; wave energy converter; WEC

## 1. Introduction

Ocean wave energy is an emerging field in renewable energy research. Energy exists in various forms in the ocean, and waves are one of the largest marine resources as well the most widely accessible [1]. Compared to wind energy, ocean wave energy has a higher power density; however, wave energy technology is still in the early stages of development and thus less mature than other renewable energy sources, such as solar and wind [2].

At present, a number of methods have been proposed by technology developers and researchers of wave energy converters (WECs) to convert ocean wave energy into electricity. In terms of the underlying basic concepts that define a system's operation, WECs can be categorized as oscillating water columns, overtopping devices, and oscillating bodies, which include heaving devices, pitching devices, and surging devices [3]–[5]. Many of these devices have been installed and tested in oceans and specific test sites for demonstration projects [6]–[8].

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