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Review Article

ISOLATED GRID FORMING CONTROL BY WAVE ENERGY CONVERTER FOR ISLAND ELECTRIFICATION

G.BHOOMIKA, S. MOUNIKA, K. MADHU KIRAN, S. MUBEENULLAH KHADRI

Annamacharya Institute of Technology and Sciences, Rajampet, Andhra Pradesh, India

CORRESPONDING AUTHOR
G.Bhoomika

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ABSTRACT
This extension incorporates a Genetic Algorithm (GA) into the isolated grid-forming control framework to enhance power quality in a wave-energy-based island electrification system. Unlike traditional approaches that optimize controller gains, the proposed method embeds GA directly inside a MATLAB Function block to compute an improved reference signal based on error inputs. The generated VDG output influences the generator-side control, enabling better dynamic response. The base system achieves current and voltage THDs of 4.98% and 4.97%, while the GA-based extension reduces these to 3.84% and 3.90%. The results demonstrate that integrating GA as an intelligent control signal generator can effectively minimize distortion and enhance system performance.
Keywords: *GAO, grid-forming, power quality, harmonics mitigation.*

1. INTRODUCTION

The provision of a reliable and sustainable source of electricity to remote and isolated islands is a challenge due to the high costs of fuel dependency and environmental impacts of conventional diesel fuel-based power generation technologies. The current trend of the world to cut carbon emissions and develop renewable energy technologies is intensifying interest in the provision of electricity to remote islands using local renewable resources. Referring to various renewable energy technologies, wave energy is a promising alternative to remote islands owing to its high density of energy with higher predictability than solar and wind resources. In the case of remote island power systems, since there is no main grid, the voltage and frequency have to remain regulated by the local generation units themselves. This function is required by the units since they have the capability to function on the principle of grid-forming. An active Wave Energy Converter (WEC), which can function on the principle of grid-forming, can function so as to provide stable electrical characteristics. However, the presence of uncertainties on account of ocean waves makes the development of effective control strategies difficult. To counter these challenges, a genetic algorithm-based optimization technique has been used for the optimization of the grid-forming control parameter of the wave energy converter. The genetic algorithm technique has proven effective in complicated, nonlinear, and multi-object optimization tasks, where other optimization processes often tend to result in suboptimal performance. The proposed method has been able to optimize the control gain to deliver enhanced stability, dynamic response, and suppression of deviations in the wave and loads.

The project work centers on formulating a standalone islanded grid-forming control scheme utilizing wave energy resources, optimized through a Genetic Algorithm. The proposed approach is designed to work effectively on islanded microgrids, leading to efficient self-reliant, sustainable, and self-sufficient power production, decreasing reliance on fossil fuels.

2. METHODOLOGY

1. System Model of a Wave Energy Converter (WEC)

For conducting the study, an efficient point-absorber wave energy converter design involving a permanent magnet linear generator has been designed using the MATLAB Simulink tool. This design takes into account the standard spectrum model representing irregular wave motion as well as the generation of electrical power from mechanical motions of varying frequencies.

2. Generator Side Converter Control

The power converter is designed on the generator side to facilitate it to control the amount of power that is derived from the waves. The technique applied for the control of the force of PTO is the resistive loading control technique, which is applied to control the amount of currents entering the generator.

3. DC-Link & Energy Storage Control

The battery energy storage system is interfaced with the DC bus through a bidirectional DC-DC converter. TheThe voltage and current control strategy stabilizes the DC-link voltage against numerous changes, including the intermittency of wave energy.

4. Grid Forming

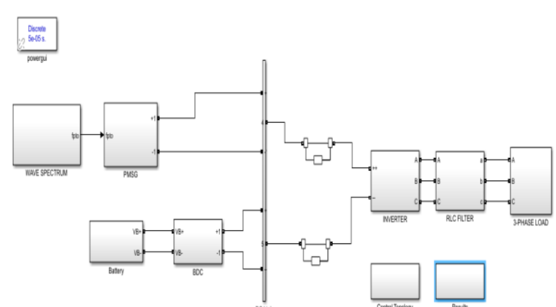
The functioning of the grid-forming mode is performed by the Load-side Inverter by producing voltage and frequency autonomously without using the PLL (phase-locking loop). The voltage and current cascade control technique in the dq reference frame is helpful in microgrid operation.

5. Genetic Algorithm (GA)-Based Optimization

The Control System is coupled with a Genetic Algorithm framework using a MATLAB Function block. The GA Search optimizes the reference signal or control parameters based on voltage and modern error reduction efforts, working towards harmonic distortion elimination and dynamic performance improvement.

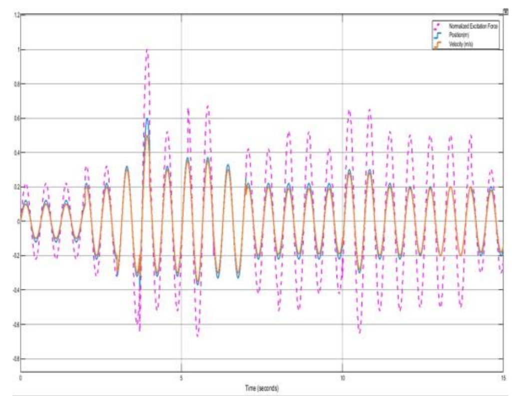
6. Performance Evaluation

The proposed control scheme in the GA-based grid-forming method is models have been verified by simulation. Chief performance indicators such as voltage regulation, frequency stability, and total harmonic



distortion (THD) terms will be discussed in comparison with the traditional control strategy.

Fig 01: Block Diagram of Proposed Method



3. RESULTS AND DISCUSSION ON WEC

Generator-Side

Fig 02: Normalized excitation force, position

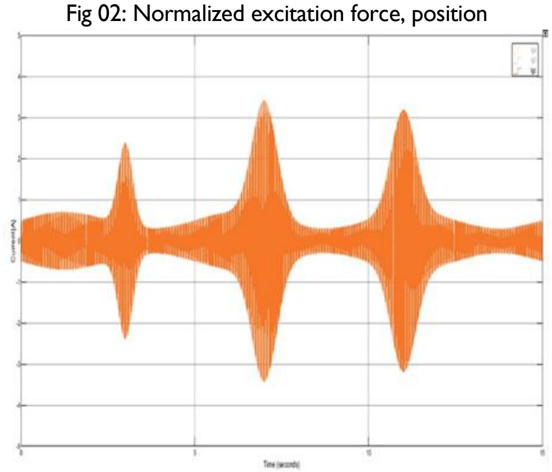


Fig 03: PMSG Current. Velocity

Load Side

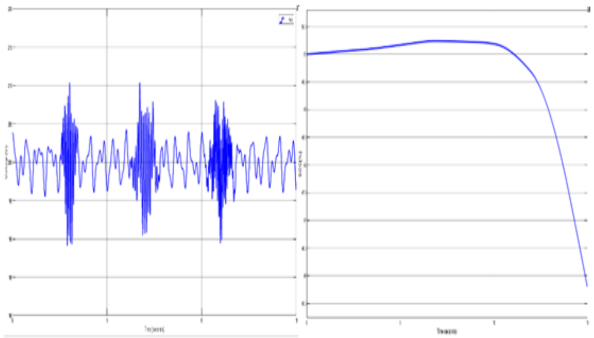


Fig 04: (a) DC link voltage (b) Battery's SOC

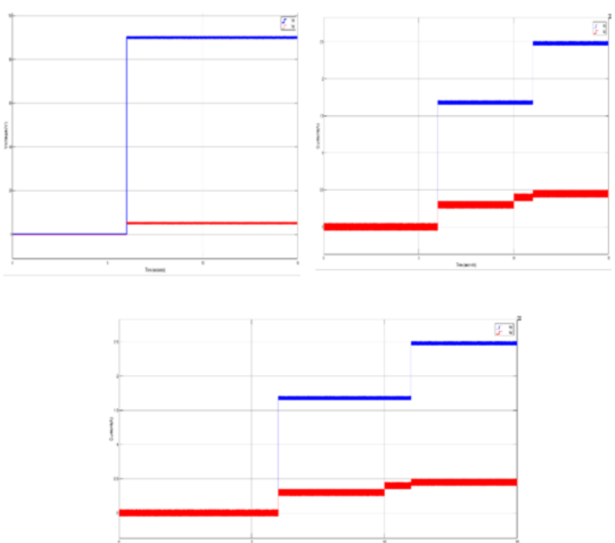


Fig 05: (a) Voltage in dq frame, (b) Current in dq frame, (c) Load power.

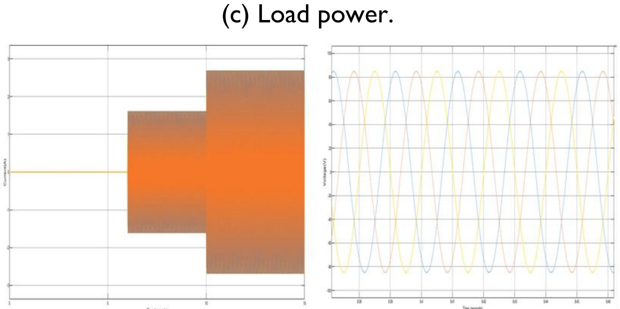


Fig 06: FThree-phase load Figure 5. Three-phase load

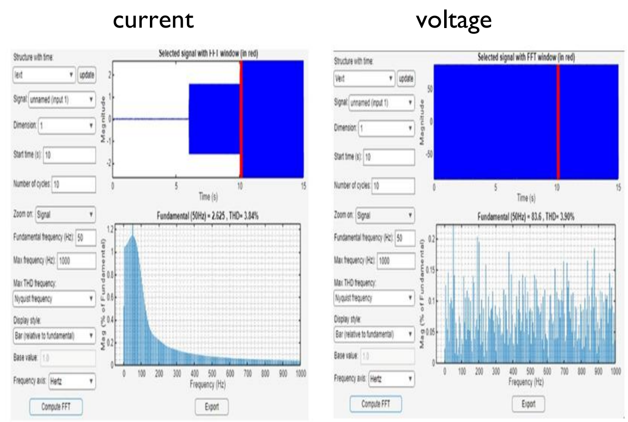


Fig 07: (a) THD value of load current (3.84%) (b) THD value of load voltage (3.90%).

4. CONCLUSION

It has the task of presenting the extension of the basic model using the integration of a Genetic Algorithm in a MATLAB Function block aimed at improving power quality. Instead of working with the gain values of the controller, the GA produces a better reference for the control signal, based on the error in the system, which directly impacts the generator-side control, making the outputs behave in a smoother manner. The use of the reference provided by the GA see improvements in the THD values of the system, with that of the current load being brought to 3.84% and that of the voltage to 3.90%, thus proving the affectivity of the use of the genetic algorithm in the generation of the references.

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